Traumatic Brain Injury in Iowa: An Analysis of Core Surveillance Data 2008-2010

Report to the Advisory Council on Brain Injuries

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Table of Contents

LISTE OF FIGURES

LISTE OF TABLES

EXECUTIVE SUMMARY

Purpose of the Report

Traumatic Brain Injury (TBI) is a major public health problem in Iowa. If you asked most people if they knew someone who has sustained a concussion or hit their head in a fall or automobile accident, they would reply "yes", however if you asked the same person if they knew someone with a TBI, they might respond "no." Many people do not realize what a TBI is. This report intends to present a picture of the silent epidemic of TBI by using vital records and hospital discharge data to raise awareness among policymakers, researchers and the general public about the magnitude and cost of TBI in Iowa.

Results Highlights

TBI numbers and rates

For the first time in the history of TBI surveillance in Iowa, the numbers and rates of TBI deaths are decreasing. Although deaths are decreasing, hospitalizations and emergency department (ED) visits resulting from TBI are steadily increasing.

From 2008 to 2010, there were, on average, 334 (compared to 545 in 2006-2008) TBI-related deaths per year. For every death from TBI in Iowa, there were three Iowans hospitalized and 32 who sought services in an emergency department. During the reporting period, on average, 33% of Iowans who lost their lives to injury (1,672), 10% of those hospitalized (16,289) or 7% of those who visited the emergency department visits (258,660) because of injury, did so because of TBI.

Iowa's TBI age-adjusted mortality rate is consistent with the national rate. The mortality rate stayed close to 18 deaths per 100,000 Iowans with an age-adjusted rate of 17 per 100,000. The age-adjusted mortality rate for counties with less than 10,000 was 27 per 100,000 and was 74% higher than in counties with more than 50,000 people (13.9 per 100,000).

TBI mortality and morbidity cases were predominantly Caucasian males. Individuals over the age of 65 were more likely to die or be hospitalized for TBI. For ED visits, the age distribution displayed a bimodal distribution in the form of a U-shape with a higher peak among people 24 years and younger.

Leading causes of TBI

Nearly 70% of TBI deaths and over 80% of the TBI hospitalizations and ED visits were due to unintentional injuries. Intentional injuries, including suicide attempts and assaults, constituted 34% of TBI deaths, five percent of TBI related hospitalizations and eight percent of TBI related ED visits.

The three leading causes of TBI deaths were by order of magnitude fall, firearm and MVC. Suicide and homicide (Intentional injuries) averaged 162 deaths, surpassing motor vehicle crashes (MVC) with an average of 140 in the causation of TBI deaths. Fall was the leading cause of TBI deaths, hospitalizations and ED visits. The leading cause of TBI death among Whites was MVC followed by fall, whereas in Blacks the leading cause of TBI related death was firearm followed by MVC.

MVC was the main cause of TBI deaths for Iowans under the age of 35 followed by firearm. The proportion of deaths due to MVC equaled the proportion of firearm deaths in Iowans between the ages of 35 and 54. Among the 55 to 64 years old, firearm was the leading cause of TBI related deaths in Iowa. Males were more likely than females to die, be hospitalized or visit the ED because of motor vehicle crashes and "being struck by or against."

TBI outcomes: discharge location and length of stays

From 2008 to 2010, 56% of hospitalized TBI cases were discharged home, 18% to long term care facilities (including skilled nurse facilities, hospice care), six percent were transferred to another inpatient hosptial, and 11% to rehabilitation services. About seven percent died during hospitalization. The proportion of cases discharged to long-term care and rehabilitation programs which increased from 24% to 30% illustrates the severity of cases that were hospitalized.

The average length of stay (LOS) for TBI hospitalizations, overall (all events), was 5.6 days (5.1 for first encounters only). The LOS for the two leading causes of TBI- Fall and MVC - was 6 and 4 days, respectively. In terms of magnitude, fall had a higher total number of hospital stays compared to MVC.

TBI related hospital charges

The three-year average total TBI related hospital charges for all cases amounted to $82 million with a mean of $40,000 (Median: $18,800). If MVC hospitalizations were typically charged to private payers, in this reporting period, fall hospitalizations were mostly billed to federal programs such as Medicare and Medicaid. The MVC and fall payment ratio (federal vs. private) were equally at 3:1 ratio. For ED visits, MVC-related TBI were still generally charged to the private sector while fall were billed to federal and private payers (ratio less than 2:1).

Conclusions

Although this report shows a stable trend of traumatic brain injury rates in Iowa and even decreasing trends because of the reduction of MVC, improved hospitalization protocols may have resulted in better triage with the worst cases reserved for hospitalizations. The true cost of TBI is not limited to hospital charges due to the proportion of cases that require ongoing care, services and supports including long-term care, which is significantly increasing over time.

Traumatic Brain Injury in Iowa

Deaths, Inpatient & Outpatient Hospital Data

2008-2010

INTRODUCTION

Termed the "silent epidemic", traumatic brain injury is the most debilitating outcome of injury characterized by the irreversibility of its damages, long-term effects on quality of life, and healthcare costs. The latest data available from the Centers for Disease Control and Prevention (CDC) estimated that nationally "1.7 million people sustained a TBI every year." Of them: 52,000 die, 275,000 will be hospitalized, and 1.365 million, nearly 80%, are treated and released from an emergency department. TBI is a contributing factor to a third (31%) of all injury-related deaths in the United States," (CDC, 2010).[1]

METHODS

Data Sources

In Iowa TBI data are collected from the following data sources: the TBI registry, death certificates, hospital inpatient data and hospital outpatient data. Inpatient and outpatient hospital data are managed by the Iowa Hospital Association (IHA); IHA provides the data without personal identifiers. Census population data estimates from 2008-2010 were used to compute rates; and age-adjustment when presented was based on the 2000 US census population.

Analysis

Individuals diagnosed with TBI were selected from the inpatient and outpatient hospital record database using the ICD9 codes identified by the Iowa Legislature as defining brain injuries. In the Iowa Code 641 chapter 21, brain injury means "any clinically evident brain damage resulting from trauma or anoxia which temporarily or permanently impairs a person's physical or cognitive functions."
The cause and type of injury was determined by the external causes of injury or E-codes.
Deaths were selected from vital records data using ICD 10 codes as recommended by the State Injury Prevention Department Agency guide to injury surveillance (STIPDA, 2004). Individuals, diagnosed with TBI were selected from the inpatient and outpatient hospital database using the codes listed in Table 1. In cases where injury was identified as the primary cause of death, hospitalization or ED visit; IC9 codes for traumatic brain injury were searched in eight diagnostic fields. In this report, non-Iowa residents were excluded from the analysis. The analysis in this report was limited to "first encounter" cases, meaning a patients that transferred from one hospital to another or who were admitted from an emergency department to the hospital were excluded. The use of the first encounters in this report should be a closer estimate of the true incidence rate of TBI in Iowa.

Demographic characteristics and other indicators, such as causes, length of stay, discharge disposition and charges, are assessed using three-year averages (2008 to 2010). Following the analysis guidelines, the intent (unintentional, suicide, homicide) was presented; however the analysis of causes (based on E-codes) was considered independently of intent. Causes reflect the mechanism of the injury, such as fall, motor vehicle crashes (MVC), firearm, suffocation (strangulation/hanging), burning/fire, and "other specified" or "not otherwise specified."

Whenever adequate, the leading causes of TBI were ranked and shown when the magnitude was high enough. A category of causes labeled "Other", which combined several causes with smaller frequencies along with the unknown causes, was created. However, since this category did not represent a homogenous group, it was not used in the comparison or ranking.

Because Iowa is characterized as a rural state, counties were stratified into the following categories: less than 10,000, 10 to 20,000, 20 to 50,000 and greater than 50,000 residents. County rates were calculated and subsequently age-adjusted using the US 2000 census.

The Statistical Analysis System (SAS version 9.1, Cary North Carolina) software was used for data management and analysis. Frequencies were generated with SAS software; rates were calculated using Iowa census population estimates. All age-adjustments were performed using the direct method (see definition in appendix) with the 5-year age strata proportional weights provided by CDC.

The average annual crude rates were calculated by averaging the frequencies and dividing by the average populations. Maps were used to illustrate the burden of TBI by county with age-adjusted rate. County population data were obtained through the state data center housed at the state library. Whenever appropriate, stacked bar chart was used to limit the cluttering effect of multiple columns. In those charts, the reader would consider every stacked column like a pie chart. The total value of the column (as in pie chart) should be 100%.

Limitations

Limitations in this report pertain to the nature of the inpatient and outpatient hospital data. The purpose of hospital discharge data is primarily for patient or insurance billing and secondarily for surveillance. In many cases, key information is missing from the discharge data; this includes race information and external cause of the injury. For example an injury to the head may be coded but the discharge data lacks the cause of the injury. The magnitude of missing E-code data and race information is such that the impact and mechanism of injury by race may be underestimated or misleading.

Table 1: International classification of diseasE-codes ninth and tenth revision for TBI

ICD 9	Label from IAC 641,21	ICD 10	Label from CDC
Traumatic Brain Injury			
348.1	Resulting from physical agents	S01.0–S01.9	Open wound of head
800.00–800.99	Fracture of vault of skull.	S02.0, S02.1, S02.3, S02.7–S02.9	Fracture of skull and facial bones
801.00–801.99	Fracture of base of skull.	S04.0	Injury of optic nerve and pathways
803.00–803.99	Other and unqualified skull fractures.	S06.0–S06.9	Intracranial injury
804.00–804.99	Multiple fractures involving skull or face with other bones.	S07.0, S07.1, S07.8, S07.9	Crushing injury of head
850.00–850.99	Concussion.	S09.7–S09.9	Other and unspecified injuries of head
851.00–851.99	Cerebral laceration and contusion.	T01.0	Open wounds involving head with neck
852.00–852.59	Subarachnoid, subdural, and extradural hemorrhage, following injury.	T02.0	Fractures involving head with neck
853.00–853.19	Other and unspecified intracranial hemorrhage following injury.	T04.0	Crushing injuries involving head with neck
854.00–854.19	Intracranial injury of other and unspecified nature.	T06.0	Injuries of brain and cranial nerves with injuries of nerves and spinal cord at neck level
994.1	Drowning and other nonfatal submersion.	T90.1, T90.2, T90.4, T90.5, T90.8, T90.9	Sequelae of injuries of head
994.7	Asphyxiation and strangulation		

RESULTS

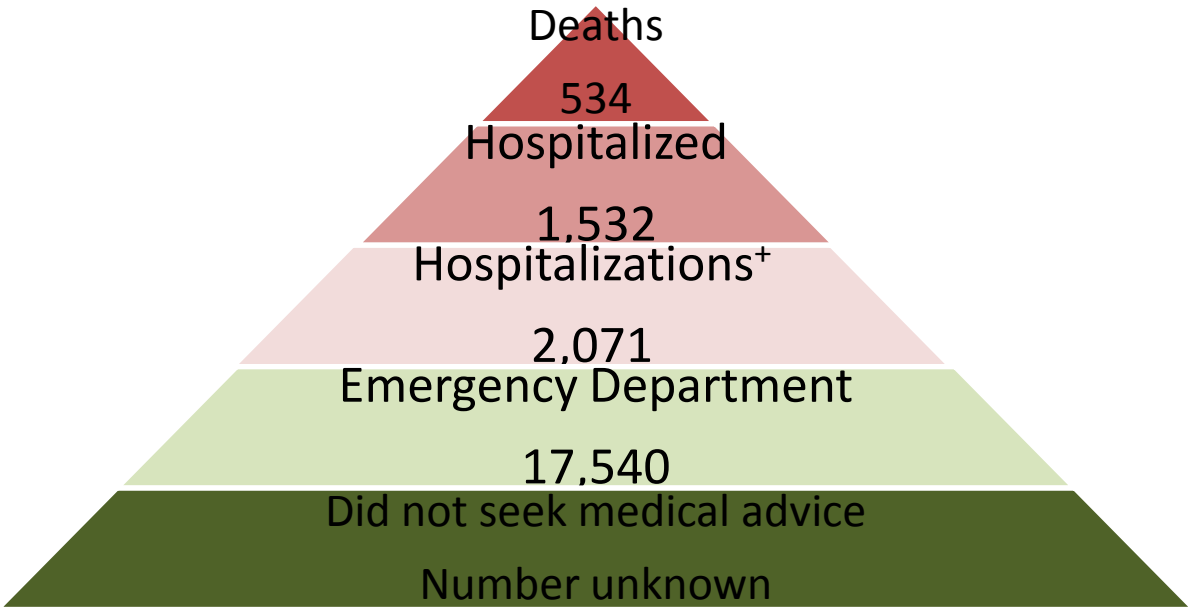
PART ONE: TRAUMATIC BRAIN INJURY EPIDEMIOLOGY

The Injury Pyramid

From 2008 to 2010, traumatic brain injury caused, on average annually, 534 deaths (reduced from 545), 1,532 people hospitalized (reduced from 1,591) and 17,540 ED visitors (reduced from 17,696) in Iowa. On average, there were 2,071 hospital admissions, which indicate that 26% of those cases could be readmissions or transfers. The overall burden of TBI in Iowa is certainly underestimated as some authors reported that 25% of mild concussions may not seek treatment or use other sources of medical care, such as doctor's office, outpatient setting and other health centers.[2] Compared to previous years, the three-year averages of TBI deaths, hospitalized cases and ED visits showed, respectively, 3%, 4%, and 9% decrease. The percentage of readmissions and transfers also decreased from 41% in 2006-2008 to 26% in the 2008-2010 periods.

Compared to all other injuries, traumatic brain injury (TBI) still corresponded to 30% of all injury deaths, 10% of injury hospitalizations and 7% of all emergency department (ED) visits. TBI deaths account for only a small percentage of TBI cases. The relative proportional ratio between deaths, hospitalizations and ED visits did not change. For every Iowan who died from TBI, three were hospitalized and 30 visited the ED.

Figure 1: Traumatic Brain Injury Pyramid (3-Year average), 2008-2010



Notes: + old calculation method counting events, which include readmissions or transfers

Demographics

TBI Deaths, Hospitalizations and ED Visit Rates by Year and County Size

Except for ED visits, mortality and morbidity rates in Iowa were stable from 2008 to 2010 (Table 2). The three-year average (2008-2010) numbers of deaths (534) and hospitalizations (2,071) were lower than the previous three-year average (2006-2008). Compared to the previous three-year average, mortality rate of 17 per 100,000 was not significantly lower than the 18 per 100,000 Iowans. However, it is moving in the right direction.

Iowans residing in counties with a population of less than 50,000 were more likely to die from TBI than individuals living in a county with a population over 50,000. The age-adjusted mortality rate for counties with less than 10,000 was 27 per 100,000 and was 74% times higher than in counties with more than 50,000 people (13.9 per 100,000).

The overall rate of Iowans who were hospitalized for TBI mirrored the mortality rates. Hospitalization rates adjusted to the 2000 census from 2006 to 2008 remained stable at 46.9 and 47.6 hospitalizations per 100,000. Counties with less than 50,000 people had greater rates of hospitalizations than those with more than 50,000 people. While most rates declined over the county size strata, counties with population 20-50,000 showed a huge increase (85%) in the average number of TBI hospitalizations from 391 (2006-2008) to 727 (2008-2010).

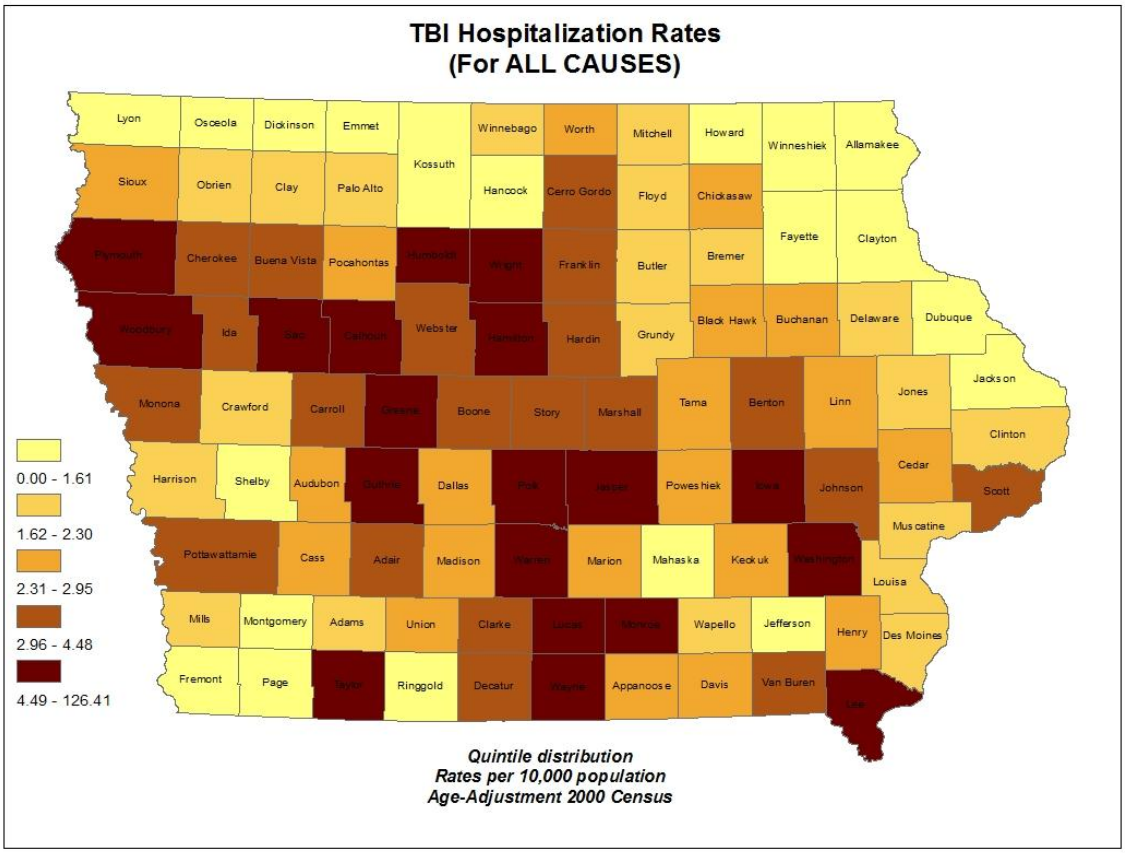
In terms of ED visit rates, a trend reversion is observed as the age-adjusted ED visit rates were higher in counties with bigger populations, which may imply people in rural areas were more likely not to go to the ED for TBI. The rates per 100,000 people for ED visits increased 14% from 2006 to 2008. Counties with a population less than 50,000 people had lower rates than counties with population size greater than 50,000 people. The mapping of the county specific rates shows centrally located counties presenting rates in the highest quartile and significantly greater than the state average.

Table 2: TBI mortality, hospitalizations and ED visit rates per 100,000, 2008-2010

	Deaths		Hospitalized		Visited the ED	
Characteristics	**N**	**Rate (Adj.)**	**N**	**Rate (Adj.)**	**N**	**Rate (Adj.)**
Year						
2008	554	18.4 (17.0)	1,574	52.4 (47.6)	18,658	621.4 (618.3)
2009	521	17.3 (15.8)	1,482	49.3 (44.7)	16,766	557.4 (553.4)
2010	528	17.3 (15.7)	1,541	50.6 (45.7	17,197	564.5 (560.9)
Average	534	17.7 (16.1)	1,532	50.8 (46.0)	17,540	581.6 (577.5)
Location*						
>50,000	210	14.2 (13.9)	547	36.6 (35.9)	8,974	604.2 (597.3)
20-50,000	152	21.1 (18.9)	727	100.3 (90.4)	3,751	520.4 (519.9)
10-20,000	132	19.2 (17.5)	215	31.2 (25.9)	2930	427.3 (432.7)
<10,000	34	27.4 (24.3)	43	35.2 (30.6)	498	401.9 (416.0)

Notes: population estimates are three-year census averages from 2008-2010. N= total number; Adj. =Adjusted rate; county >50,000 (bolded values) are used as reference; *numbers may not add up due to missing county information.

Figure 2: All Causes of TBI Hospitalization Age-adjusted Rates (per 10,000) by County, 2008-2010



Distribution of TBI Deaths, Hospitalizations and ED Visits by Race, Gender and Age Group

In the 2008-2010 data, the mortality and morbidity cases were mostly Whites and males (71%). The proportion of whites among TBI deaths were (96%), among the TBI hospitalized cases (84%) and among ED visits (81%).

The average age of TBI deaths was 53 years, ranging from less than one year to over 100 years. The age distribution of TBI deaths showed a net reduction among people less than 25 years of age (15% vs. 18%) but an increase among people more than 65 years of age (41% vs. 39%) from 2006-2008 to 2008-2010 reporting periods. The proportion of TBI deaths between the age of 25 and 64 years ranged from 8% to 13%. While TBI mortality count decreased in magnitude among most age groups, it increased a bit among the 65 and older Iowans.

The average age of TBI hospitalizations was also 53 years and the age range spanned from less than one year to over 100 years old. The TBI hospitalizations were evenly distributed across the age groups (8-14%), except for those less than 15 years (4%) and those over 65 years of age (38%). Iowans age 65 and older were also more likely to be hospitalized for TBI. Emergency department patients had an average age of 35 years. Individuals younger than 25 years of age represented 53% of all ED visits

Comparing the burden of TBI by race should be used with caution as race misclassification may artificially overburden one compared to the other races (Table 3).

Table 3: Demographic Distribution of TBI mortality and morbidity, hospitalizations and ED visits- (2008-2010)

	Deaths		Hospitalizations		ED Visits	
Characteristics	**N**	**%**	**N**	**%**	**N**	**%**
Race						
Whites	492	95.9	1289	84.5	13,092	81.0
Blacks	13	2.6	47	3.1	789	4.9
Other Races	2	0.5	48	3.2	451	2.8
Unknown	5	1.0	140	9.2	1,827	11.3
Gender						
Male	377	71.4	900	59.0	8,751	56.5
Female	151	28.6	625	41.0	7,408	43.5
Age Groups						
<15	17	3.3	125	8.2	5,252	32.5
15 to 24	62	11.7	160	10.5	2,967	18.4
25 to 34	51	9.7	117	7.7	1,636	10.1
35 to 44	54	10.2	120	7.9	1,259	7.8
45 to 54	71	13.4	167	11.0	1,286	8.0
55 to 64	55	10.5	156	10.3	981	6.1
Over 65	217	41.2	678	44.5	2,777	17.2

Notes: Race information in Hospital Discharge Data was missing in 9% in hospital and 11% in ED visit cases;

Severity, Mechanism and Causes of TBI

Major progress with regards to the external causes of injury collection was noted. E-codes were filled out in all cases of deaths but 15% of hospitalizations for TBI lacked E-codes and 6% for ED visits. This report consists mostly of percent distribution; however, age-adjusted rates are presented when comparing rates across gender or county.

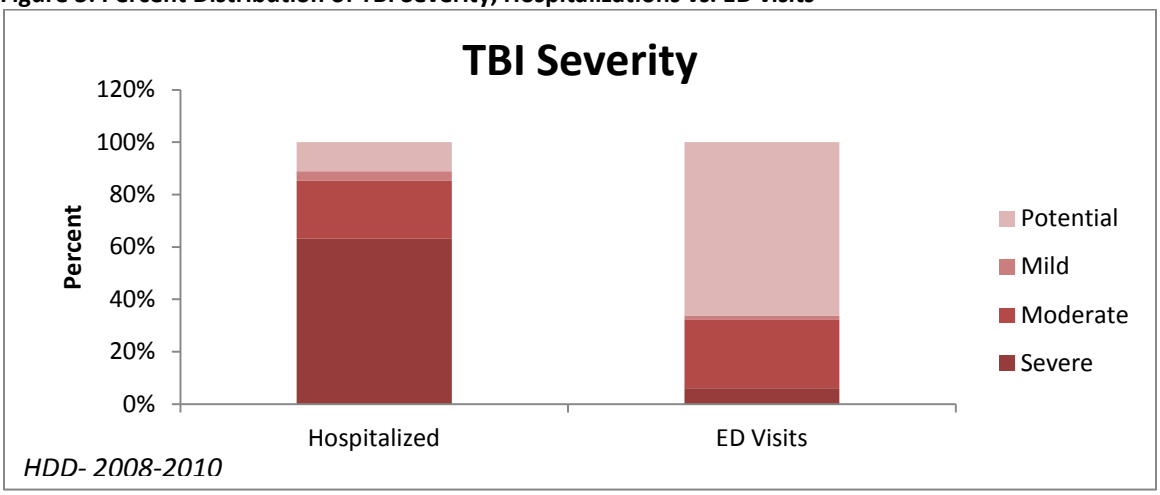
TBI Severity among Hospitalized and Emergency Department Cases

The TBI severity distribution showed that 80% of TBI hospitalization cases were severe (63%) to moderately severe (22%). Mild TBI or potential concussion consisted of 15% of the cases. Emergency department cases were made up of mostly potential TBI diagnosis 66% with less than 32% being diagnosed as moderate to severe TBI (Figure 4).

About 67% of TBI deaths were due to unintentional injuries. Compared to the 2006-2008 report, there was a slight increase in self-inflected TBI deaths, which represented quarter of the total cases. This increase in the proportion of suicide related TBI may be due to a better determination of the intent associated with deaths. All other categories decreased except for suicide, which increased about 10%.

Nearly 80% or more of hospitalizations and ED visits that resulted in a TBI diagnosis were due to unintentional injuries. Assaults (homicide) constituted five percent of TBI related hospitalizations and eight percent of TBI related ED visits (Table 4).

Figure 3: Percent Distribution of TBI Severity, Hospitalizations vs. ED visits



Note: Each column/bar should be read like a pie chart with each segment equivalent to a slice of the pie.

Table 4: Distribution of Average TBI Deaths, Hospitalizations and ED visits by Intent (2008-2010)

	Deaths		Hospitalizations		ED Visits	
INTENT	**N**	**%**	**N**	**%**	**N**	**%**
Unintentional	357	66.8	1,234	80.5	13,627	77.7
Suicide	137	25.7	10	0.7	17	0.1
Homicide	25	4.7	73	4.8	1,469	8.4
Other/Undetermined	15	2.8	215	14.0	1,414	8.1

Leading Causes of TBI Deaths, Hospitalizations and Emergency Department Visits

Leading causes of TBI among all Iowans

Fall has become the leading cause of TBI deaths, hospitalizations and ED visits. The three leading causes of TBI irrespective of conditions (death, hospitalization or ED visits) have been: Fall, MVC, Struck-by/against (including sports and assaults).

Overall, in the 2008-2010 reporting period, the leading causes of TBI deaths were, by order of magnitude, Fall with 174 cases (increased from 153 previously), firearm with 150 cases (increased from 138 previously) and MVC with 140 cases (decreased from 163 previously). While there was a 14% decrease in the number of TBI related MVC, firearm and fall related deaths increased 9% and 14%, respectively. The rise of firearm-related TBI deaths to second leading cause is a matter of concern; however, it is due to the combination of an increase in firearm deaths and a decrease in MVC. Furthermore, firearm-related TBI deaths are correlated to the 3-year average increase in the number of suicides, from 331 (2005-2007) to 367 (2008-2010).[3]

For hospitalizations and ED visits, the leading causes of TBI after fall were Struck-by/ against (including assaults and sports) and MVC. The leading causes of hospitalizations were fall (752), motor vehicle crashes (333) and struck by/against (81). The leading causes of ED visits were fall (7,769), Struck by/against (3,733) and MVC (1,873). Except for fall, TBI hospitalization and ED visits decreased consistently. For clarity of the report a category of causes -"Other" - was created by combining all other causes of TBI, including poisoning, suffocation, causes not specified, unknown and missing, (Table 5).

Table 5: Leading Causes of TBI Deaths, Hospitalizations and ED Visits, 2006-2008

Causes	Deaths (Rank)	Hospitalizations (Rank)	ED Visits (Rank)
FALL	174 (1)	752 (1)	7,769 (1)
FIREARM	150 (2)	9	12
MVC	140 (3)	333 (2)	1,873 (3)
STRUCK BY/AGAINST	5	81 (3)	3,733 (2)
OTHER	65	366	4,153
Total	534	1,532	17,540

Notes: ED= emergency department visits; MVC= motor vehicle crashes; OTHER = CUT/PIERCE, DROWNING, FIRE/FLAME, MACHINERY, NATURAL/ENVIR, NEC (not expressly coded), SPEC (specified), OTHER LAND TRANSPORT, OTHER PEDAL CYC (cyclist), OTHER PEDESTRIAN, OTHER SPEC, OTHER TRANSPORT, POISONING, SUFFOCATION;

Percent Distribution of TBI Causes by Age

These percents reported are column percents, meaning the comparison is specific to the corresponding age group and the sum should total 100% approximately, accounting for rounding errors. In these following charts, each column should be read like a pie chart with each segment representing a slice of the percent distribution.

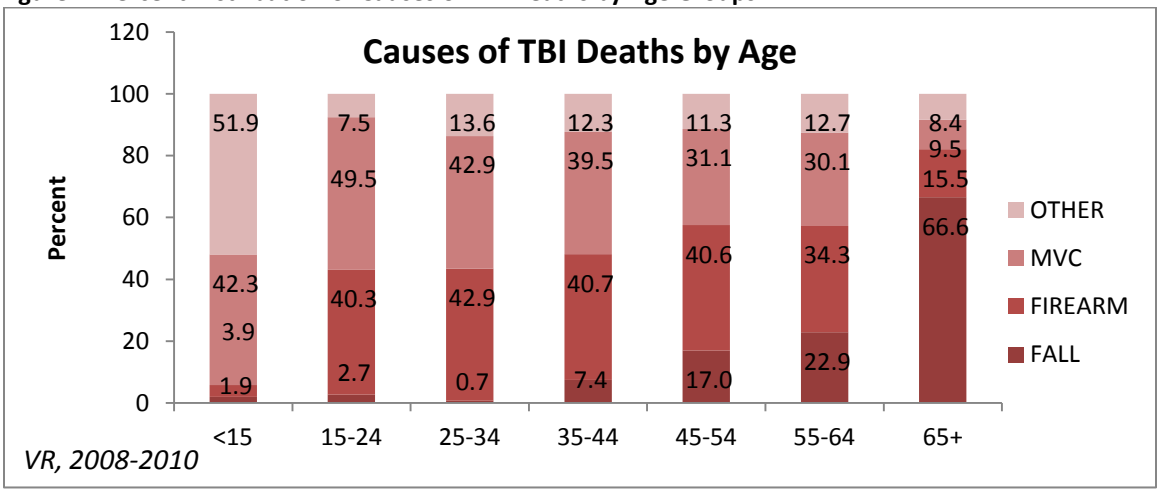
Among Iowans under the age of 25, the main cause of TBI related deaths were MVC (50%). MVC is followed by firearm deaths, particularly in the 15-24 age range (40%). The proportion of deaths due to MVC equaled that of firearm (43%) among Iowans between the ages of 25 and 34 years old. By 55-64

years of age, firearm was the leading cause of TBI deaths (37%) followed by MVC (24%). Among Iowans older than 65, the leading cause of deaths was fall (67%) followed by firearm (15%) and MVC (8%), (Figure 4). Compared to previous reports (2006-2008), the proportion of fall and firearm deaths among the 65 and older increased respectively from 58% to 67% and 12% to 15%; whereas it decreased for MVC from 18% to 8%.

For hospitalizations, MVC are highest among the 15-44 years old, ranging from 34% to 58%. Fall ranked second in the magnitude of TBI hospitalization among the 15-44, ranging from 14% to 27%, while it was the leading cause of hospitalizations starting among youths under 15 and among the older population, 45 and older. Among the 65 and older, fall constituted 68% of TBI hospitalizations. Struck-by/ against was the third leading cause among young adults 15-24 (Figure5).

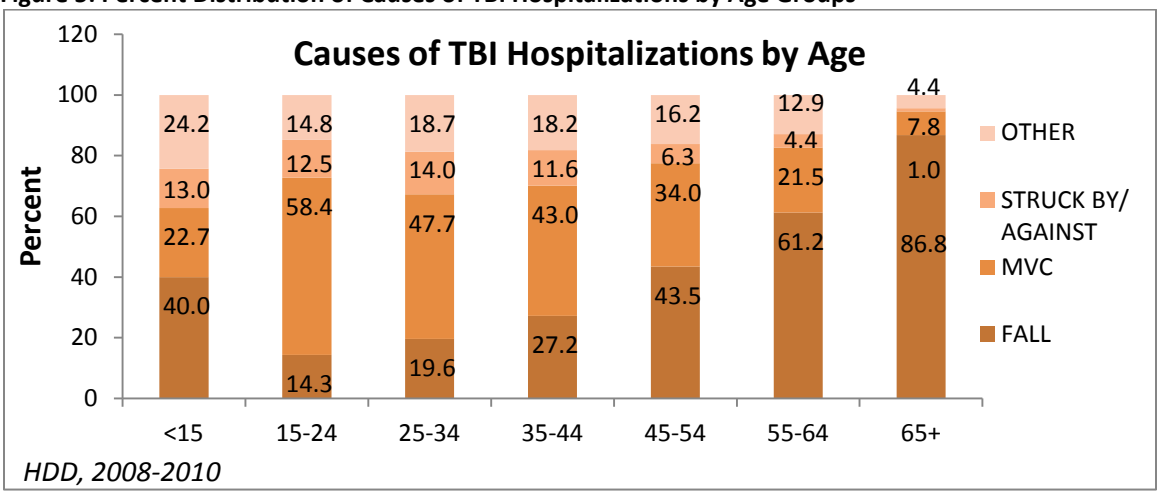
The emergency department visits presented a different picture (Figure 6). Fall was the leading cause of ED visits among Iowans under 15 years of age (31%) and among those over the age of 45. The percentage distribution of fall by age followed a bimodal V-like shape with higher percentage on the external age groups, less than 15 years of age and 55 and older. Struck-by/against was the first leading cause of TBI in the 15 to 34 age groups ranging from 33% to 38%. MVC were the second leading cause of TBI ED visits among the young adults 15-24 (24%)

Figure 4: Percent Distribution of Causes of TBI Deaths by Age Groups



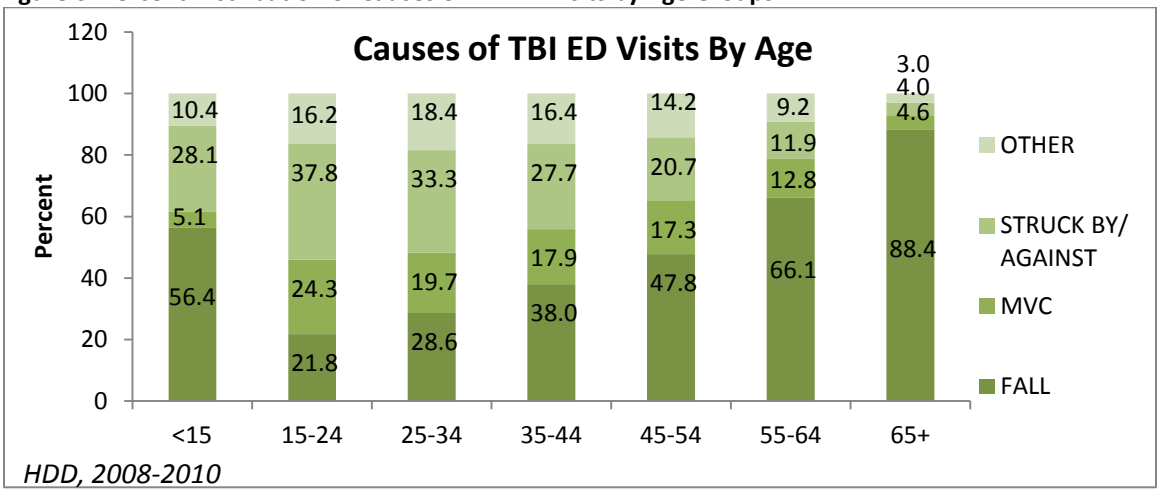
<u>Note</u>: Each column/bar should be read like a pie chart with each segment equivalent to a slice of the pie; VR= IDPH vital Records.

Figure 5: Percent Distribution of Causes of TBI Hospitalizations by Age Groups



Note: Each column/bar should be read like a pie chart with each segment equivalent to a slice of the pie; HDD= Hospital Discharge Data

Figure 6: Percent Distribution of Causes of TBI ED Visits by Age Groups



Note: Each column/bar should be read like a pie chart with each segment equivalent to a slice of the pie; HDD= Hospital Discharge Data

Percent Distribution of TBI Causes by Race

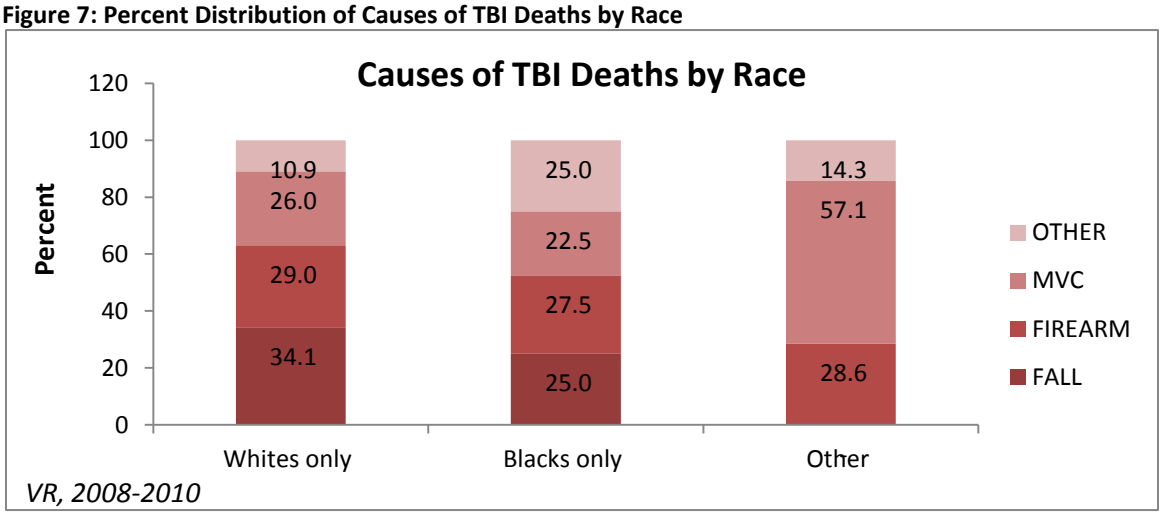
Among Whites, the leading cause of TBI deaths was fall (34%) followed by firearm (29%) and MVC (26%); whereas in Blacks - 27% of all deaths were due to firearm followed by fall (25%) and MVC (22%), (Figure 7). We noted an important variability among Blacks across the years with proportion of firearm related deaths down while fall is up from the previous report. This variability is due to the lower number of TBI deaths among Blacks averaging 13 cases per year. For people in the "Other" racial category, including Hispanics, Asians, and Natives etc., people died mostly from MVC (41%). Firearm and fall followed with a respective proportion of 23% and 12% of TBI deaths.

The category of causes labeled "Other" represents the combination of all other causes, such as poisoning, suffocation, machinery, etc. and unknown causes, such as not specified or missing, and therefore is excluded from the comparison with other causes.

The hospital distribution showed Whites and Other racial groups suffered more from fall than MVC. While MVC were the leading cause of hospitalizations among Blacks (36%), Struck-by/against was the third leading cause of hospitalizations in Blacks (16%). Among the Other racial category, struck by/against was the third leading cause of TBI hospitalizations (9%), (Figure 8).

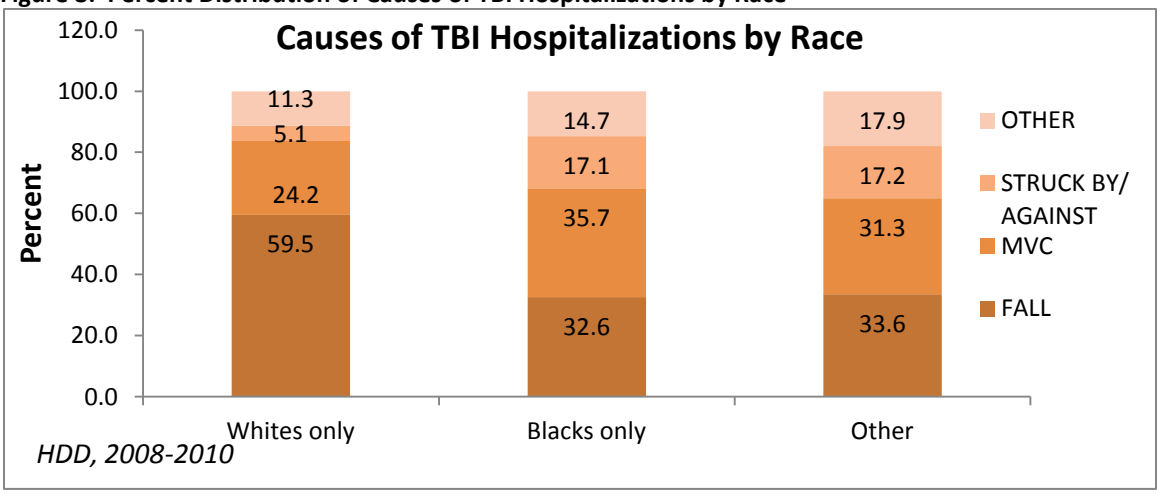
For ED visits (Figure 9), fall was the leading cause of TBI among all racial groups followed by Struck by /against. MVC was the third leading cause of TBI among all racial groups.

Figure 7: Percent Distribution of Causes of TBI Deaths by Race



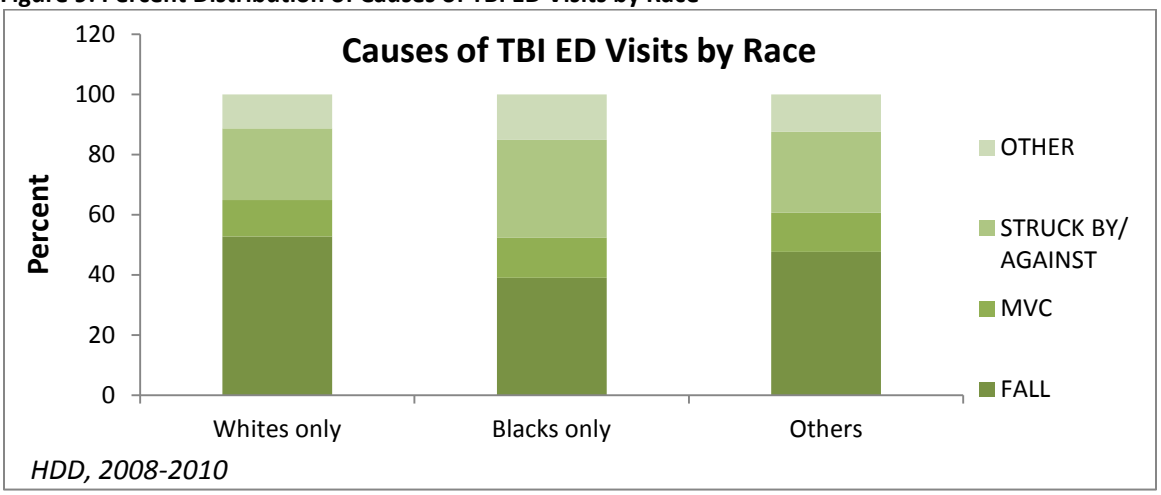
Note: Each column/bar should be read like a pie chart with each segment equivalent to a slice of the pie; VR= Vital Records;

Figure 8: Percent Distribution of Causes of TBI Hospitalizations by Race



Note: Each column/bar should be read like a pie chart with each segment equivalent to a slice of the pie; HDD= Hospital Discharge Data;

Figure 9: Percent Distribution of Causes of TBI ED Visits by Race



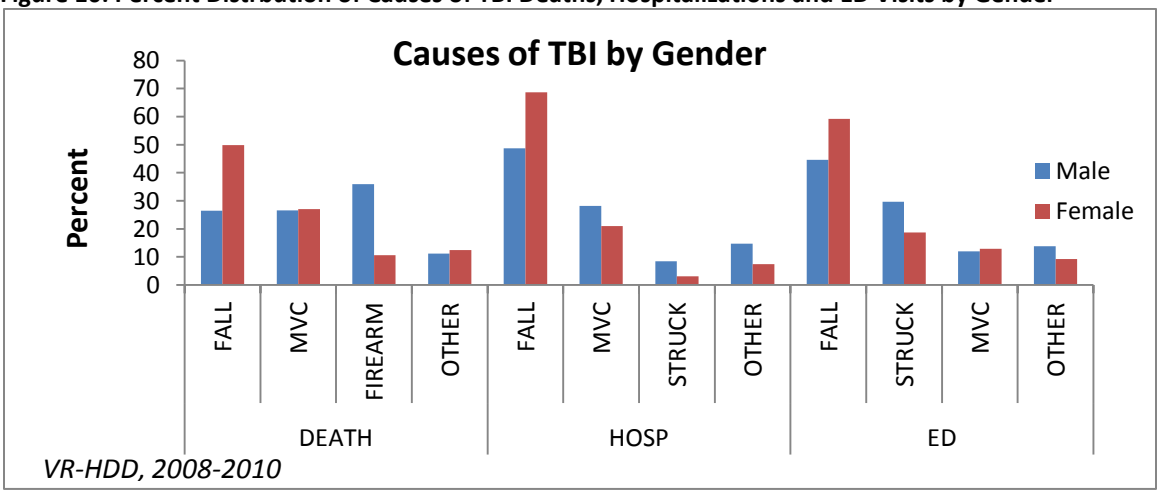
Note: Each column/bar should be read like a pie chart with each segment equivalent to a slice of the pie; HDD= Hospital Discharge Data;

Percent Distribution of TBI Causes by Gender

Although most Fall-related TBI deaths were males (58%), the proportion of fall among female deaths (50%), hospitalizations (69%) or visiting the ED (59%) because of TBI was higher compared to males.

There was no difference in the distribution of MVC-related TBI deaths by gender. Males were more likely than females to be hospitalized or visit the ED because of firearm and being struck by /against, (Figure 10). Males constituted most of firearm deaths (89%), hospitalizations (91%) and ED visits (88%).

Figure 10: Percent Distrbution of Causes of TBI Deaths, Hospitalizations and ED Visits by Gender



Notes: Percent is gender specific; VR= Vital Records, HDD: Hospital discharge data; HOSP= hospitalizations, ED= emergency department visits;

TBI Deaths, Hospitalizations, ED Visits Rates by Causes and County Size

Since the percentage distribution of TBI deaths, hospitalizations and ED visits was not meaningful without adjusting for county size, age-adjusted rates per 100,000 were calculated to make valid county category comparison. The age-adjustment eliminates the effect of older age in those counties with older populations, which in turn will estimate the risk of falling in those county groups. Counties were categorized into four groups depending on their size. A three-year total population from the census estimates was computed and used to calculate the age-adjusted rates by county category. The US census 2000 population was used for age adjustment.

As shown earlier, the three leading causes of TBI deaths in Iowa were in order of magnitude: Fall, firearm, and MVC. When stratified by county size, the leading cause of deaths in counties with a population greater than 50,000 was fall followed by firearm and MVC. In counties with population 20-50,000, MVC was the second leading cause of TBI deaths after fall followed by firearm. However in counties with less than 20,000 people, MVC remained the leading cause of TBI deaths. In counties with 10-20,000 people, fall was the second leading cause and among counties with less than 10,000 people, firearm was the second leading cause of TBI deaths, (Table 6).

Table 6: Three-Year Total Number of TBI Deaths by Causes, Rank and Average by County Size

CAUSE	>50,000 (Rank)	20-50,000 (Rank)	10-20,000 (Rank)	<10,000 (Rank)	3-YEAR TOTAL	3-YEAR AVERAGE
FALL	235 (1)	153 (1)	113 (2)	21 (3)	522 (1)	174 (1)
FIREARM	194 (2)	120 (3)	110 (3)	28 (2)	452 (2)	150 (2)
MVC	132 (3)	131 (2)	120 (1)	38 (1)	421 (3)	140 (3)
NOT SPECIFIED	17	9	11	0	37	12
…	…	…	…	..	..	..
TOTAL (3 YR Deaths)	629	452	394	101	1576	525

Notes: MVC= Motor vehicle crashes; NEC=not expressly coded; SPEC=Other Specified; Natural/Envir.=Natural/Environmental;

Using age-adjusted rates per 100,000 population, counties with less than 50,000 people presented higher rates of MVC, firearm related deaths and struck-by/against than counties with population greater than 50,000 people (Figure 11). Compared to counties with population greater than 50,000 (reference group), the relative risk for dying from fall after controlling for age was 45% lower in counties with a population between 10 to 20,000, and 60% lower for counties with population less than 10,000. The risk for dying from firearm was 20, 30 and 70% higher, in order, for counties with 20-50,000, 10-20,000, and less than 10,000 people. After controlling for the ageing population (age-adjustment) the 2008-2010 report found a lower risk of fall-related deaths among counties with population under 20,000 compared to counties with bigger populations.

As for TBI related hospitalizations, counties with population 20-50,000 had higher age-adjusted rates regardless of causes than other county sizes (Figure 12). Again the differences from 2006-2008 report are due to age-adjustment. Counties with population greater than 50,000 had the second highest rate of TBI hospitalizations due to fall after counties with population 20-50,000. Hospitalization age-adjusted rates for Struck by/against in counties with population 20-50,000 were twice as high as in counties with population greater than 50,000.

There were no significant differences in the rates of TBI ED visits by county size except for fall. The age-adjusted rates of TBI related ED visits for fall increased with increasing population size (Figure 13).

Figure 11: TBI Mortality Rates per 100,000 by Causes and County Size

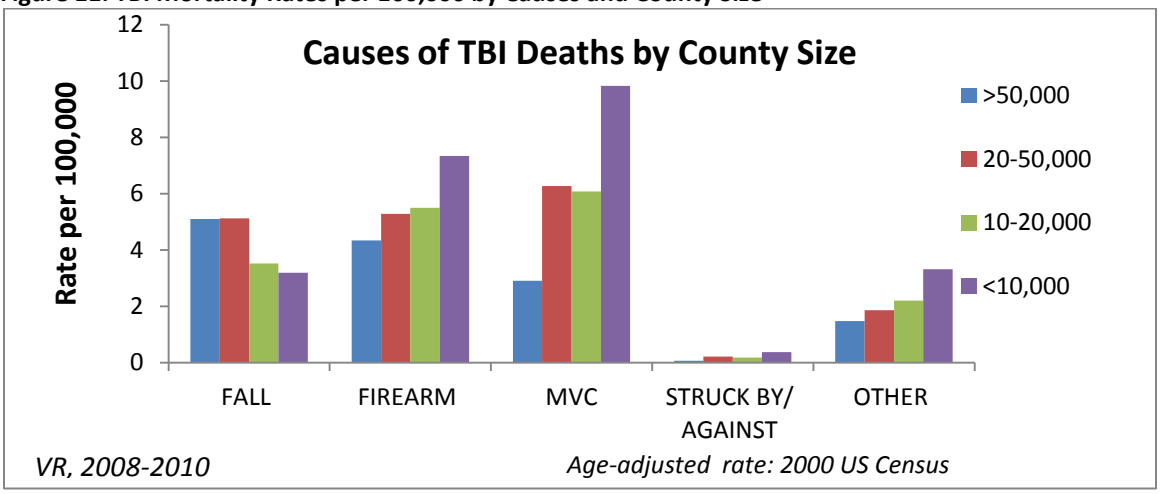


Figure 12: TBI Hospitalization Rates per 100,000 by Causes and County Size

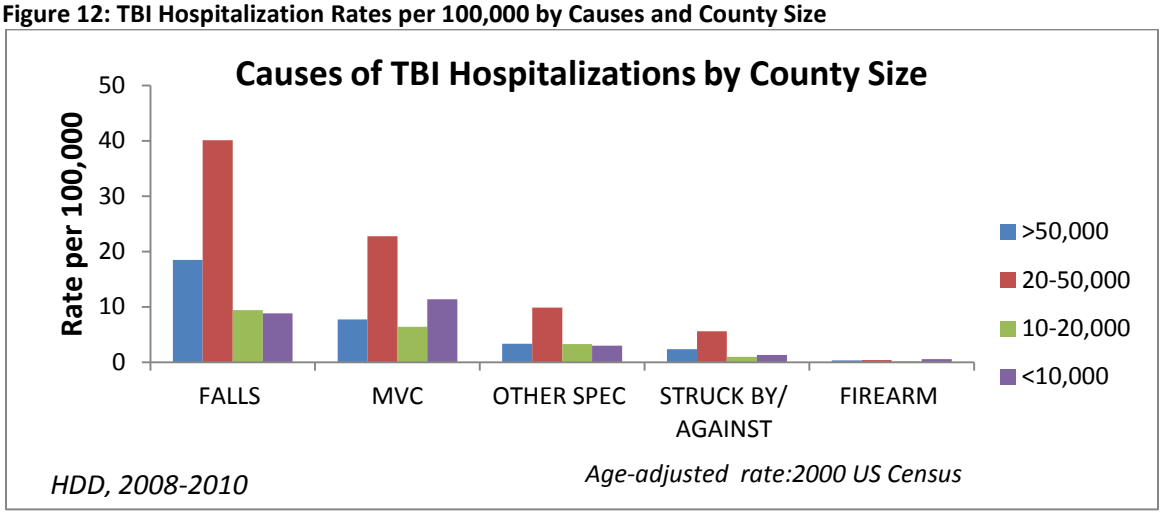
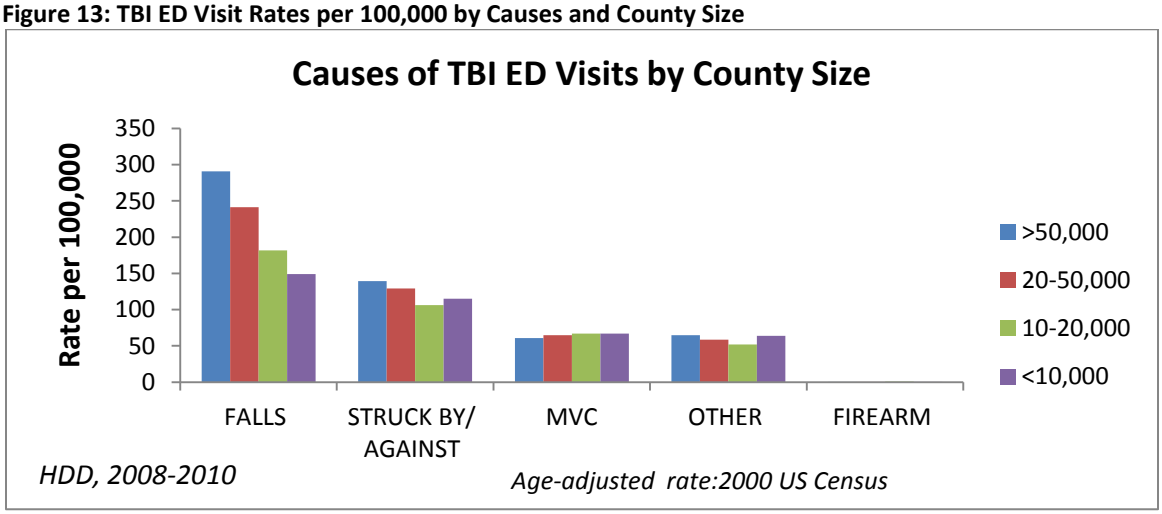


Figure 13: TBI ED Visit Rates per 100,000 by Causes and County Size



PART TWO: THREE LEADING CAUSES of TBI MORTALITY and MORBIDITY (Fall, Firearm and MVC)

The major causes of TBI deaths, hospitalizations and ED visits were fall and MVC. In previous reports, MVC was the leading cause of TBI deaths and fall contributing the most to the burden of TBI hospitalization and ED visits. In the 2008-2010 reports, fall has become the leading cause of TBI deaths, hospitalizations and ED visits. This finding is associated with a decrease in overall MVC in the state, which explains the decrease in MVC-related TBI deaths. Therefore, firearm rose as the second leading cause of TBI deaths. Struck by/ against was third as leading cause of TBI hospitalizations and second in ED visits. This section will address specifically the two leading causes of TBI deaths (fall and firearm), hospitalization and ED visits (fall and MVC).

Fall-related TBI

There were on average 174 fall-related TBI deaths (increased from 153 cases in 2006-2008), 752 hospitalizations (increased from 686 cases) and 7,764 ED visits (decreased from 8,207). Across the gender strata, the proportion of Fall-related TBI deaths, hospitalizations and ED visits increased with age except for ED visits, which showed a higher proportion among younger and older population. The percentage distribution by age was different when comparing males and females.

Demographics

The proportion of fall-related TBI deaths was higher among males age 45 to 74 than among females in the same age range but was higher among females age 75+ compared to males (Figure 14). Hospitalizations for fall-related TBI followed the same trend as deaths. The proportion of fall related TBI leading to emergency department visits was higher among Iowans under age 25 compared to other age groups (Figure 15). ED visits for fall-related TBI followed a "V" distribution with increased visits for individuals aged 0-24 and 45-85+. The proportion was higher among males under the age of 25 than among females; while it was higher among females over the age of 45 compared to males in the same age category (Figure 16).

Table 7: Total Number and Percent Distribution of Fall Related TBI Deaths, Hospitalizations, ED visits by Age Groups and Gender

	DEATHS		HOSPITALIZATIONS		ED VISITS	
Age Groups	Male N (%)	Female N (%)	Male N (%)	Female N (%)	Male N (%)	Female N (%)
<5	0 (0.0)	0 (0.4)	15 (4.1)	11 (3.1)	1,004 (27.4)	776 (18.9)
05--14	0 (0.0)	0 (0.0)	11 (2.9)	5 (1.4)	599 (16.4)	357 (8.7)
15--24	1(1.7)	0 (0.0)	17 (4.6)	4 (1.2)	351 (9.6)	331 (8.1)
25-34	0(0.3)	0 (0.0)	16 (4.4)	4 (1.2)	209 (5.7)	226 (5.5)
35-44	3 (3.4)	0(0.0)	20 (5.4)	10 (2.7)	209 (5.7)	235 (5.7)
45-54	10 (10.1)	2(2.7)	44 (11.7)	19 (5.3)	255 (7.0)	318 (7.8)
55-64	8 (8.1)	4 (6.2)	51 (13.4)	32 (8.8)	265 (7.2)	342 (8.3)
65-74	15 (15.1)	8 (11.1)	57 (15.0)	45 (12.3)	235 (6.4)	362 (8.8)
75-84	31 (31.6)	21(28.9)	79 (20.8)	103 (27.9)	312 (8.5)	547 (13.3)
85+	29 (29.6)	37 (49.8)	67 (17.8)	134 (36.2)	224 (6.1)	607 (14.8)

Notes: N= 3-Year average number of cases; %= column percent; % does not equal 100 because of averaging and rounding effect; ED= emergency department;

Figure 14: Percent Distribution of TBI Deaths due to Fall by Gender and Age Groups

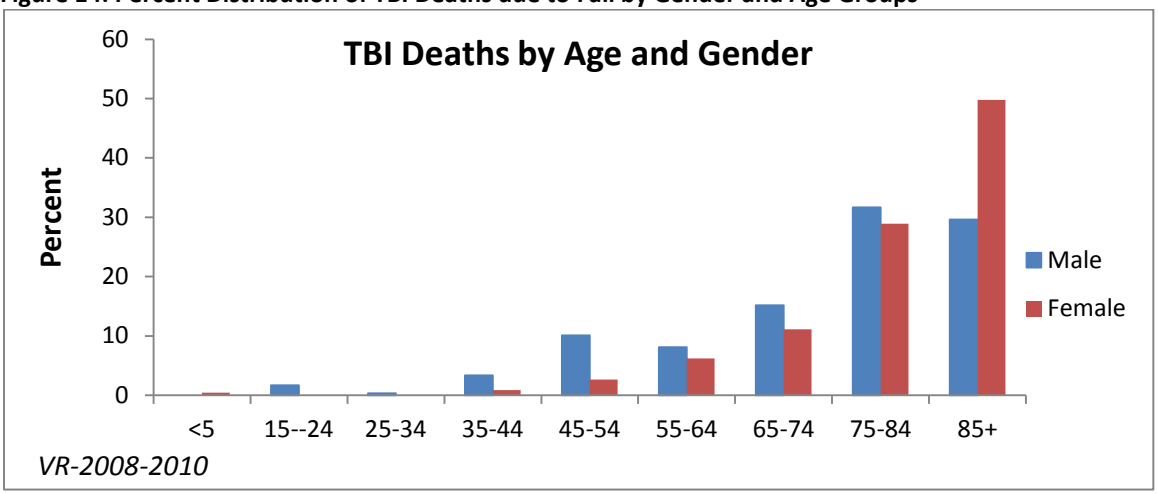


Figure 15: Percent Distribution of TBI Hospitalizations due to Fall by Gender and Age Groups

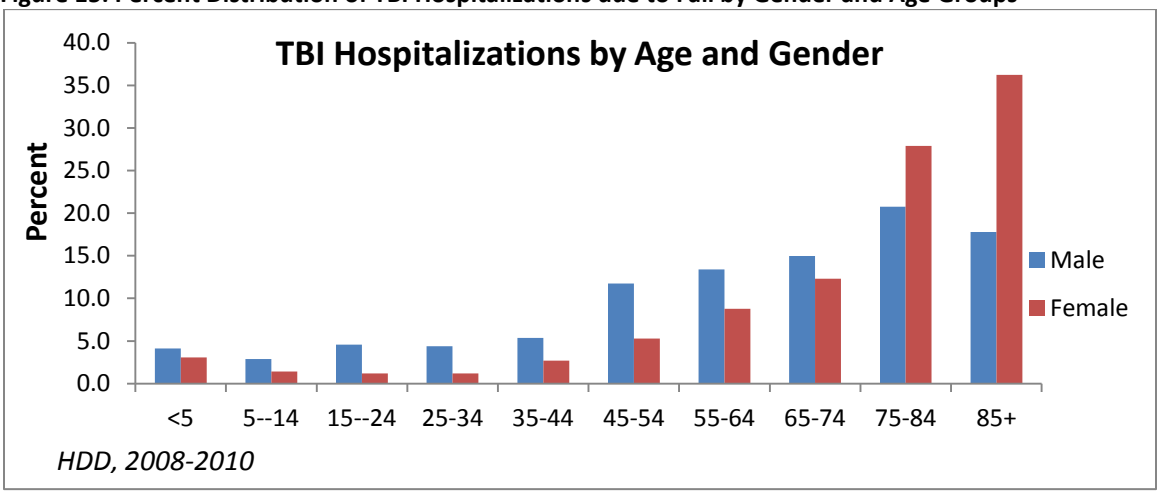
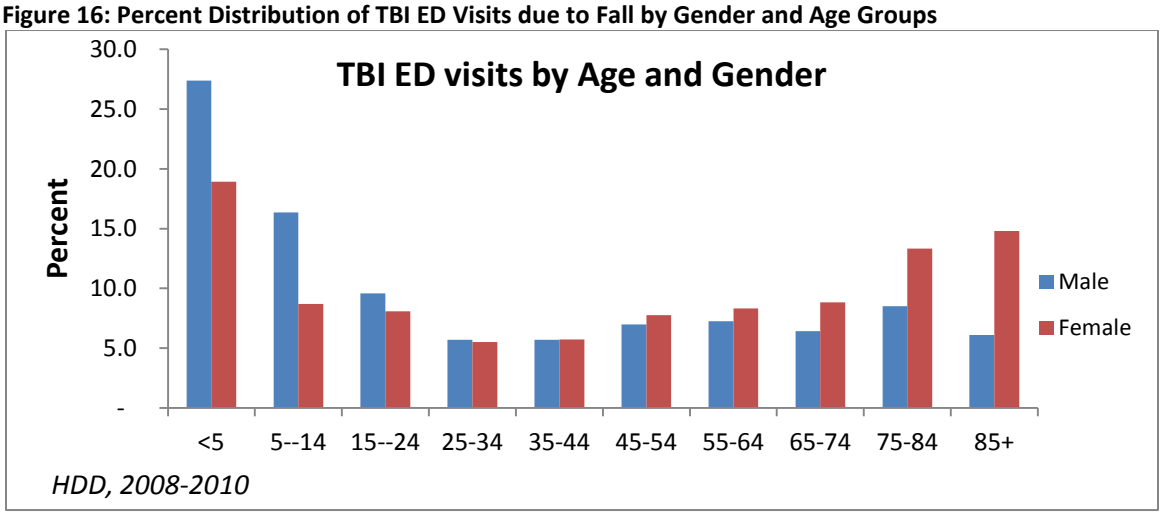


Figure 16: Percent Distribution of TBI ED Visits due to Fall by Gender and Age Groups



County Rates

Fall-related age-adjusted death rates were higher among counties with greater than 20,000 people compared to counties with less than 20,000 people (Figure 17). The trend pattern was similar for hospitalizations and ED visits. However, the hospitalization age-adjusted rates were higher among counties with population 20-50,000 than among counties with population greater than 50,000 (Figure 18). For ED visits, the age-adjusted rates were higher in counties with population of more than 50,000 people. Less populated counties had the lowest rate of hospitalization and ED visit rates (Figure 19).

The age-adjusted county specific rates demonstrated a clustering of the highest quartile in central areas except a few counties in the southern and western borders (Figure 20).

Figure 17: Age-adjusted Rates per 100,000 of Fall-related TBI Deaths by County Size

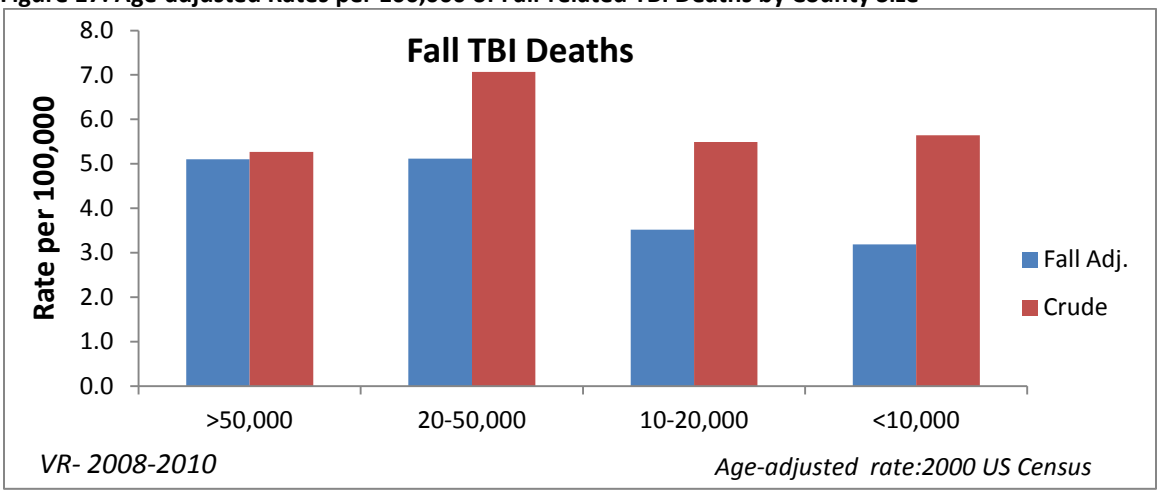


Figure 18: Age-adjusted Rates per 100,000 of Fall-related TBI Hospitalizations by County Size

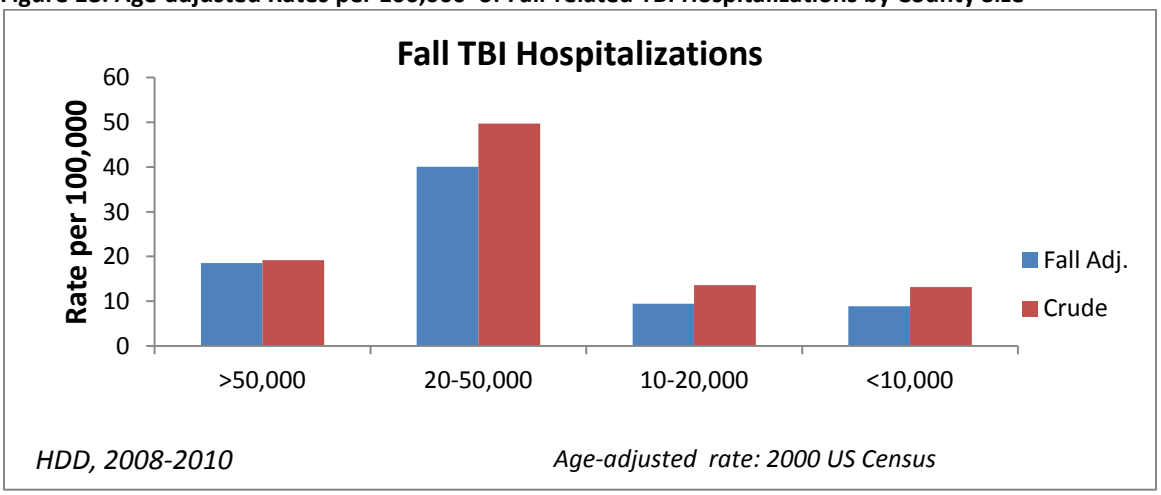


Figure 19: Age-adjusted Rates per 100,000 of Fall-related TBI ED Visits by County Size

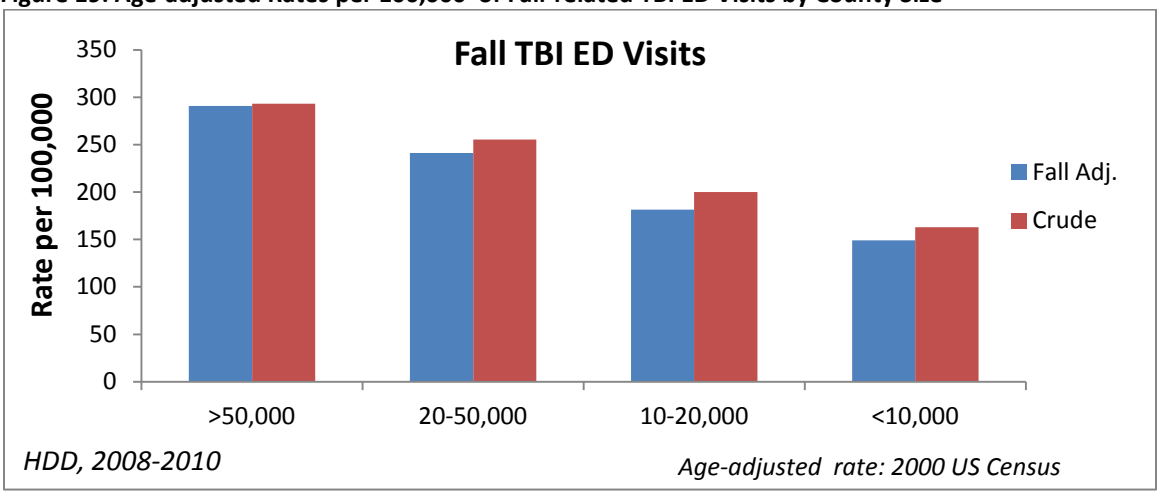
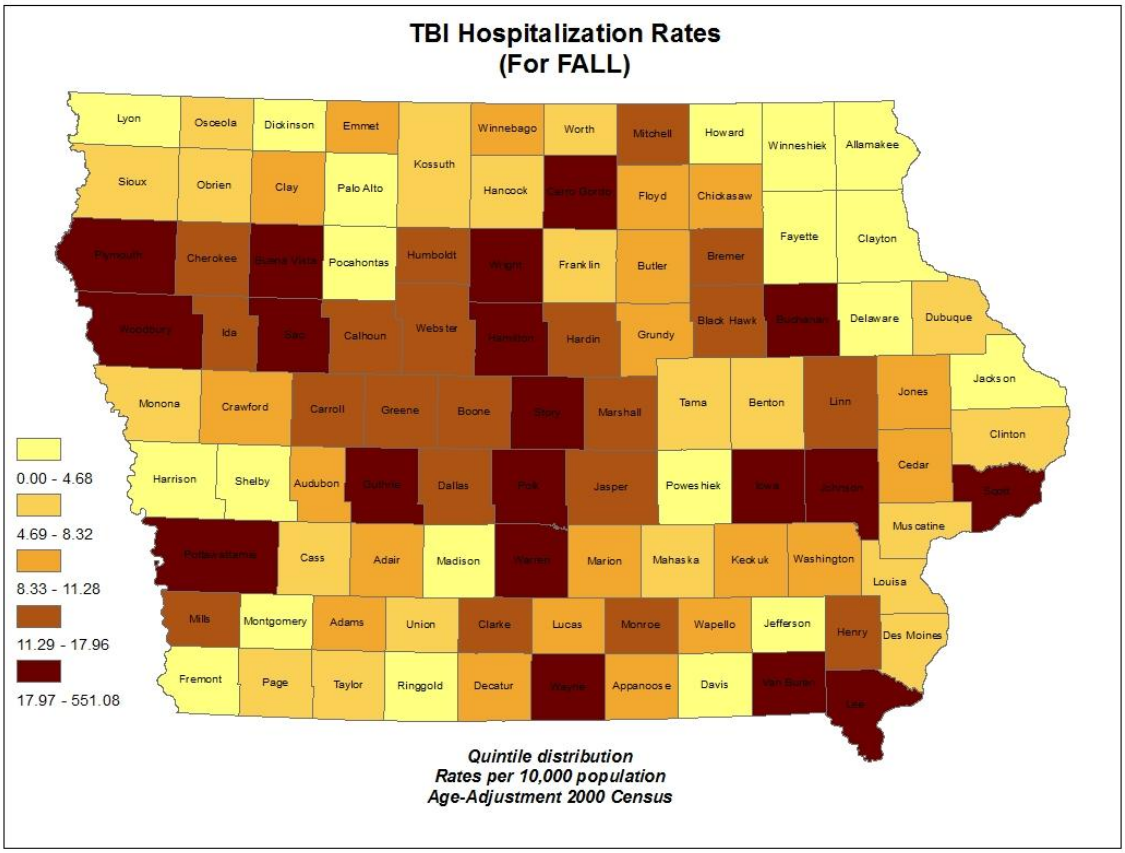


Figure 20: Fall-related TBI Hospitalization Age-adjusted Rates (per 10,000) by County, 2008-2010



Firearm-related TBI Deaths

The lethality of firearm associated injuries explains the lower number of hospitalizations and ED visits cases. The analysis was therefore limited to deaths only.

Demographics

From 2008 to 2010, the total number of firearm related TBI fatalities was 452 (annual average 150) of which 97% were Whites, 2% were Blacks, and 1% were from other races. In addition, 89% were males and 11% were females. Across all ages, the proportions were relatively equally distributed with the highest proportion among those 65 and older. Three peaks are noticeable among the 15-24, 45-54 and the 65 and older with respective percents of 17%, 19% and 22%.

The percentage distribution of firearm-related TBI was different by race and gender. Although the total number (11) of TBI deaths was low among Blacks during the 2008-2010period, 2/3 of the deaths were homicide related compared to Whites with 93% were suicides. The majority (93%) of the deaths among males were suicides and 4% homicide while among females 62% were suicides and 37% homicides. Across all age groups most of deaths were suicides except among the younger people, 15-24 and 25-34 age groups, 16% and 12% were due to homicides, respectively.

Table 8: Demographic Characteristics, Average number and Percent Distribution of Firearm related TBI Deaths by Intent

INJURY TYPE	UNINTENTIONAL N (%)*	SUICIDE N (%)*	HOMICIDE N (%)*	UNDETERMINED N (%)*	3-YEAR AVERAGE N (%) +
RACE					
Whites only	3 (0.7)	395 (92.9)	21 (4.9)	6 (1.4)	141 (97.2)
Blacks only	2 (18.2)	2 (18.2)	7 (63.6)	0 (0.0)	3 (2.1)
Others	1 (50.0)	1 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)
Unknown	1 (20.0)	2 (40.0)	2 (40.0)	0 (0.0)	1 (0.7)
GENDER					
Male	7 (1.7)	375 (92.8)	16 (4.0)	6 (1.5)	134 (89.3)
Female	0 (0.0)	30 (62.5)	18 (37.5)	0 (0.0)	16 (10.7)
AGE GROUPS					
<15	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
5--14	1 (50.0)	0 (0.0)	1 (50.0)	0 (0.0)	0 (0.0)
15--24	2 (3.0)	58 (77.3)	12 (16.0)	3 (1.5)	25 (16.9)
25-34	2 (3.0)	55 (83.3)	8 (12.1)	1 (1.5)	22 (14.9)
35-44	1 (1.5)	62 (93.9)	3 (4.5)	0 (0.0)	22 (14.9)
45-54	1 (1.2)	79 (91.9)	5 (5.8)	1 (1.2)	28 (18.9)
55-64	0 (0.0)	53 (93.0)	4 (7.0)	0 (0.0)	19 (12.8)
65+	0 (0.0)	98 (98.0)	1 (1.0)	1 (1.0)	33 (22.1)

Notes:* N= 3-year total number of cases, Percentages are row percent; + N= 3-year average number of cases, Percentages are column percent; Percentages do not equal 100% because of rounding, missing race information was not tabulated;

County Rates

Even after adjusting for age, counties with populations less than 10,000 people demonstrated significant higher rates of firearm-related TBI deaths. The firearm-related TBI age-adjusted death rate was 7.3 per 100,000. Compared to counties with population greater than 50,000 (rate=4.3 per 100,000), firearm TBI age-adjusted death rates were 23% higher in counties with 20-50,000 people (rate=5.3 per 100,000), 28% higher in counties with 10-20,000 people (rate=5.5 per 100,000), and 70% in counties with less than 10,000 people (rate=7.3 per 100,000), (Figure 21).

Firearm-related TBI age-adjusted death rates were higher in rural counties with no specific clustering. Counties in the highest quartile were border counties as well as north central counties (Figure 22).

Figure 21: Firearm-related TBI Death Rates per 100,000 by County Size

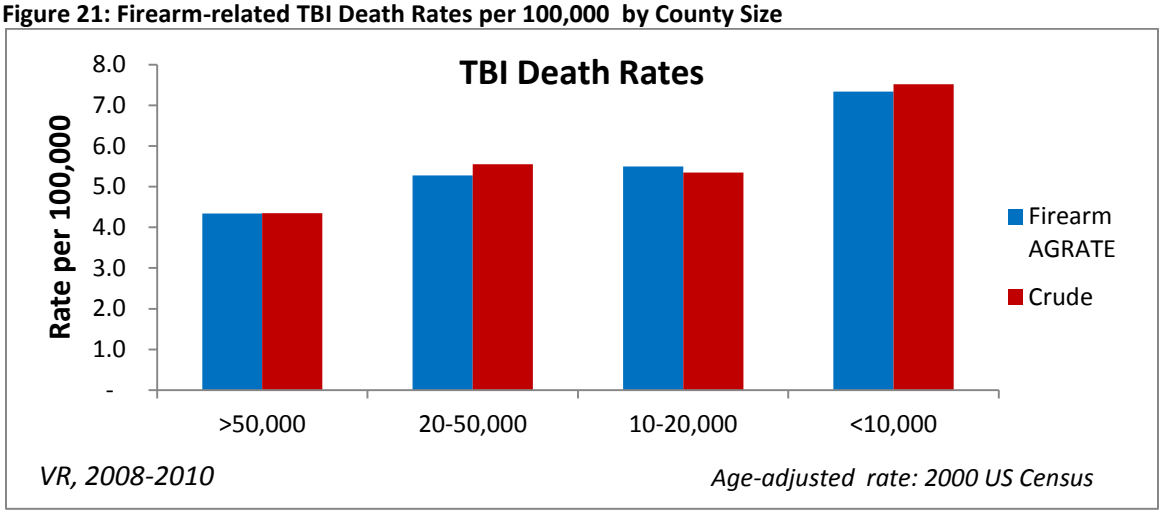
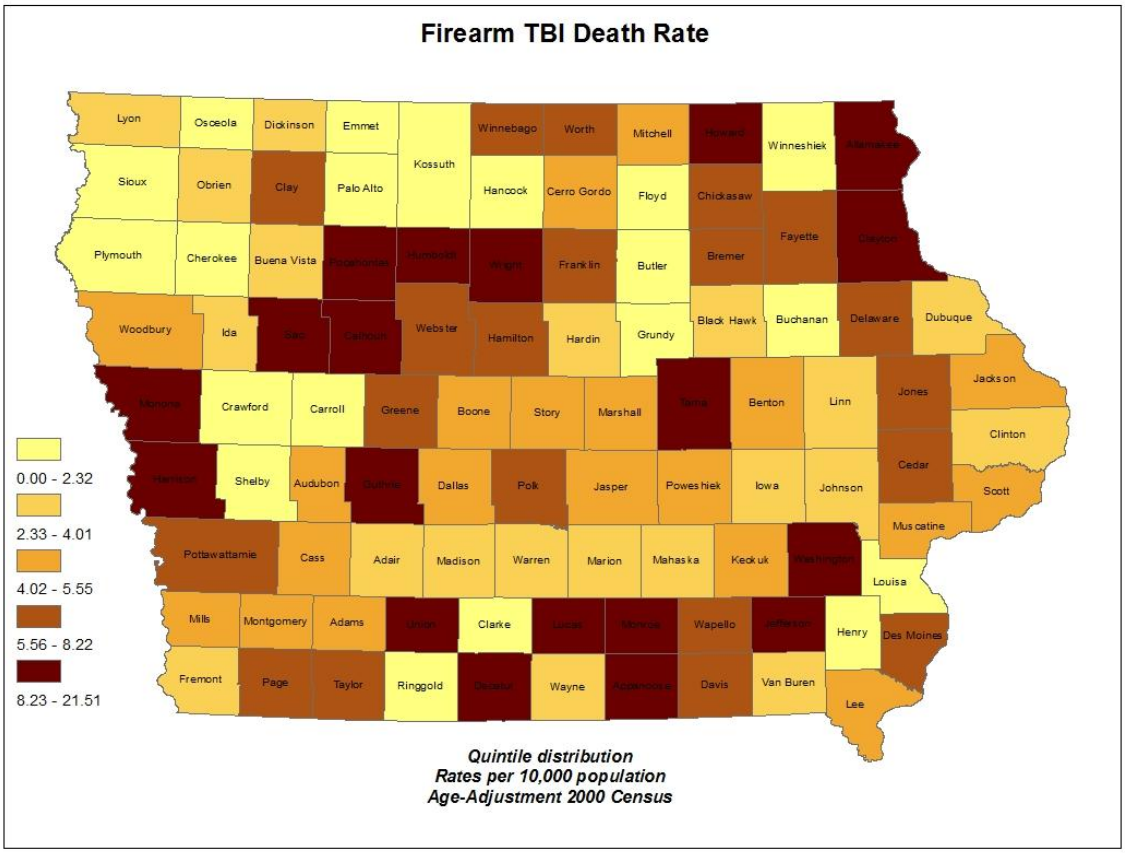


Figure 22: Firearm-related TBI Hospitalization Age-adjusted Rates (per 10,000) by County, 2008-2010



MVC-related TBI

Annually, MVC resulted in an average of 143 TBI deaths (reduced from 163 in 2006-2008), 332 people hospitalized and 1,807 people visiting the emergency departments (reduced from 2,072). There was a significant reduction of MVC-related TBI deaths and ED visits. Hospitalizations remained unchanged compared to previous years.

Demographics

Overall, males represented 71% of all MVC-related TBI deaths, 66% of MVC-related TBI hospitalizations, and 52% of all TBI ED visits. The age /gender tabulation did not show major differences in the distribution of MC-related TBI deaths, hospitalizations and ED visits.

Table 9: Demographic Characteristics, Average Number and Percent Distribution of MVC TBI Deaths, Hospitalizations and ED visits by Age Group and Gender, 2008-2010

	DEATHS		HOSPITALIZATIONS		ED VISITS	
Age Groups	Male N (%)*	Female N (%)	Male N (%)	Female N (%)	Male N (%)	Female N (%)
<5	1 (1.3)	0 (1.6)	1 (0.8)	3 (3.2)	21 (2.1)	17 (1.9)
05--14	4 (4.4)	1 (2.5)	11 (5.0)	5 (4.4)	90 (9.2)	67 (7.6)
15--24	20 (20.7)	10 (24.6)	60 (27.3)	29 (25.8)	364 (37.4)	359 (40.2)
25-34	16 (16.7)	5 (13.1)	39 (17.8)	12 (10.6)	164 (16.8)	135 (15.1)
35-44	17 (17.4)	4 (9.8)	30 (13.8)	17 (15.5)	110 (11.3)	99 (11.1)
45-54	15 (15.7)	6 (15.6)	33 (15.2)	17 (15.0)	104 (10.7)	102 (11.4)
55-64	13 (13.4)	3 (8.2)	20 (9.4)	8 (7.6)	67 (6.8)	50 (5.7)
65-74	4 (4.4)	3 (8.2)	9 (4.4)	6 (5.6)	33 (3.4)	33 (3.7)
75-84	5 (5.0)	4 (10.7)	9 (4.2)	11 (9.7)	18 (1.9)	21 (2.3)
85+	1 (1.0)	2 (5.7)	4 (2.1)	3 (2.6)	4 (0.4)	8 (1.0)
Total [+]	99 (71.0)	41 (29.0)	219 (65.9)	113 (34.1)	979 (52.3)	894 (47.7)

Notes: N= 3-year average number of cases; %= column percent calculated based on the 3-year total; [+] row percent based on 3-year total

County Size

Counties with less than 10,000 people showed higher age-adjusted rates of MVC-related TBI deaths than the others. MVC-related TBI age-adjusted death rates were about 60% higher than in counties with population 10-20,000 and 20-50,000; and were three times higher than in counties with population greater than 50,000 people (Figure 23). In terms of MVC- related hospitalizations, counties with higher populations demonstrated greater age adjusted rates than counties with less number of people (Figure 24). MVC-related TBI age-adjusted hospitalization rates were highest in counties with population 20-50,000.

MVC-related TBI age-adjusted ED visit rates increased with county size and age-adjusted rates were highest in counties with population less than 10,000. The differences with the crude rates are due to the age-adjustment as people in MVC are younger in more populated counties (Figure 25). County specific age-adjusted hospitalizations for MVC showed the highest quartile rates more distributed on the state's southern and western borders (Figure 26).

Figure 23: MVC-related TBI Death Rates per 100,000 by County Size

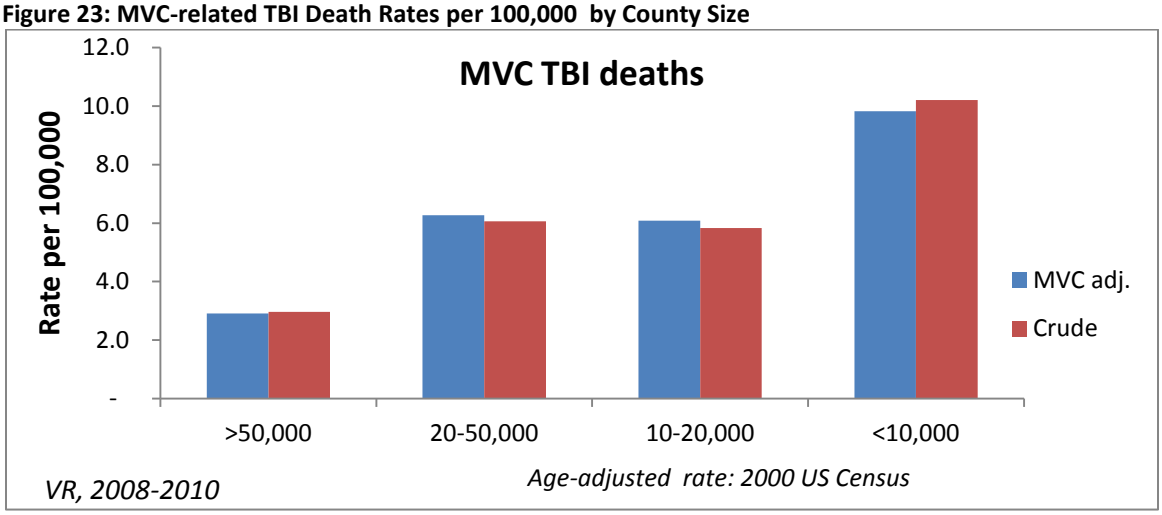


Figure 24: MVC-related Hospitalization Rates per 100,000 by County Size

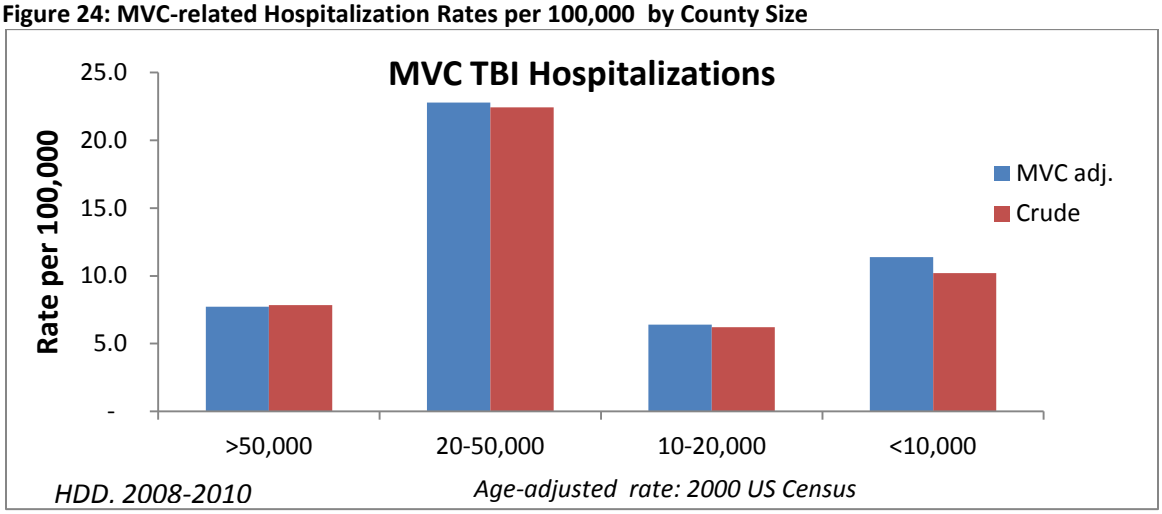


Figure 25: MVC-related TBI ED Visit Rates per 100,000 by County Size

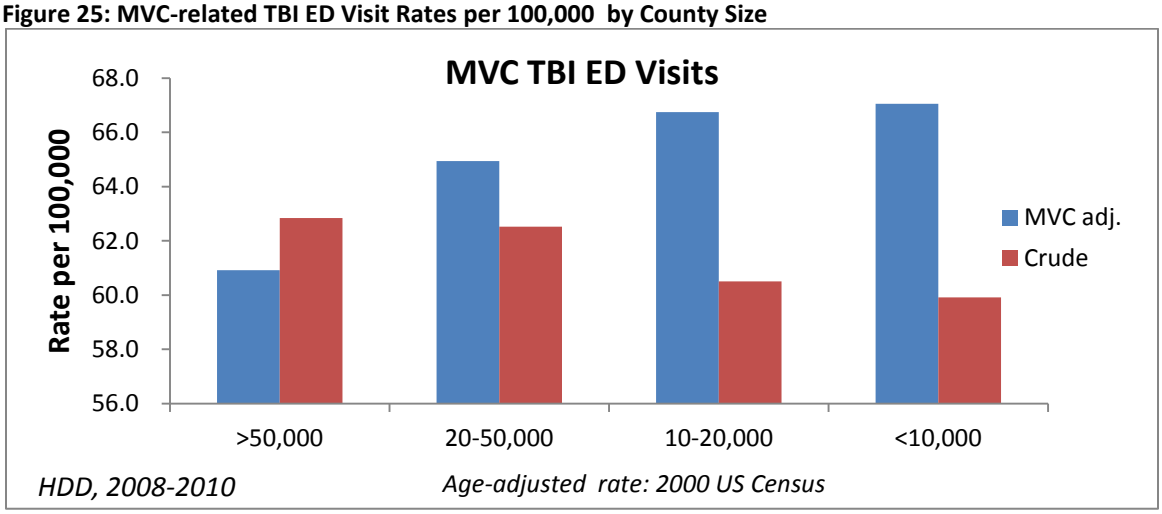
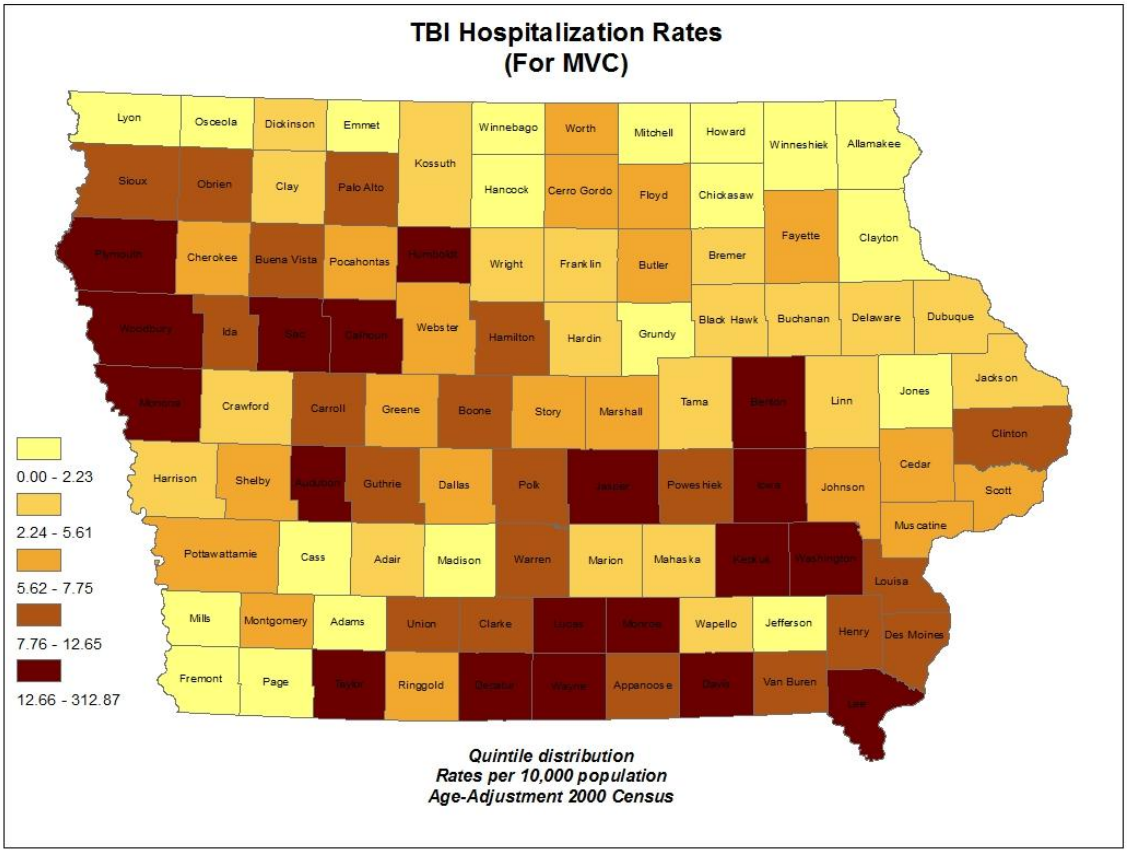


Figure 26: MVC-related TBI Hospitalization Age-adjusted Rates (per 10,000) by County, 2008-2010



Persons injured in MVC by Race, Gender and Age

Consistently across all ages, car occupants or drivers constituted the highest proportion of MVC- related TBI deaths (71%), hospitalizations (65%) and ED visits (82%). The majority of the occupant deaths were 15 to 24 years old (24%), 25 to 34 years old (18%), and 35 to 44 years old (15%). Over 16% of the occupant deaths occurred among the 65 years and older population (Table 10).

Occupant hospitalizations occurred mostly among the 15 to 24 years old (30%), 25 to 34 years old (16%) and 35 to 44 years old (13%), (Table 11). Occupant ED visits were mostly 15 to 24 years old (38%) and 25 to 34 years old (17%), (Table 12). The age distribution of occupant deaths was not significantly different from previous reports.

Motorcycle injuries represented 20% of all MVC- related TBI deaths and TBI hospitalizations, and eight percent of ED visits. Pedestrians and bicyclists consisted of seven percent of the MVC- related TBI deaths, 11% of TBI hospitalizations, and six percent of ED visits. The majority of females who died from MVC (80%), or were hospitalized (75%) or visited ED (88%) were drivers or occupants in personal car crashes**.** Males, who died (68%) or were hospitalized (61%) or visited ED (76%), were mostly drivers or occupants in personal car crashes. While the proportion of males in motorcycle TBI deaths was six times higher than that of females, the difference was 4 times higher for hospitalizations and ED visits. All motorcycle related TBI deaths were Whites, representing 20% of MVC- related TBI fatalities. Blacks and other races (including Hispanics) had a higher proportion of pedestrian deaths; however in terms of absolute values, the numbers were low compared to Whites.

Table 10: Demographic Characteristics, Average numbers and Column Percent Distribution of MVC-related TBI Deaths by Person Injured during Crashes, 2008-2010

Person Injured	OCCUPANT	MOTOR CYCLE	PEDAL CYCLIST	PEDESTRIANS	OTHER	UNSPECIFIED	3-Year Ave
3 Year Ave	99 (70.7)	28 (20.0)	2 (1.4)	6 (4.3)	0 (0.0)	3 (2.1)	140
RACE							
Whites only	266 (96.0)	83 (100.0)	5 (83.3)	15 (79.0)	2 (100.0)	11 (100.0)	127
Blacks only	6 (2.2)	0 (0.0)	1 (16.7)	2 (10.5)	0 (0.0)	0 (0.0)	3
Others	3 (1.1)	0 (0.0)	0 (0.0)	1 (5.3)	0 (0.0)	0 (0.0)	1
Unknown	2 (0.7)	0 (0.00	0 (0.0)	1 (5.3)	0 (0.0)	0 (0.0)	1
GENDER							
Male	202 (68.0)	72 (84.7)	5 (83.3)	11 (55.0)	2 (100.0)	7 (63.6)	99
Female	95 (32.0)	13 (15.3)	1 (16.7)	9 (45.0)	0 (0.0)	4 (36.4)	40
AGE GROUPS							
<15	17 (5.7)	0 (0.0)	1 (16.7)	3 (15.0)	0 (0.0)	1 (9.1)	7
15-24	71 (23.9)	14 (16.5)	0 (0.0)	4 (20.0)	0 (0.0)	3 (27.3)	30
25-34	54 (18.2)	8 (9.4)	0 (0.0)	1 (5.0)	2 (100.0)	1 (9.1)	22
35-44	44 (14.8)	17 (20.0)	0 (0.0)	2 (10.0)	0 (0.0)	1 (18.2)	21
45-54	38 (12.8)	22 (25.9)	1 (16.7)	3 (15.0)	0 (0.0)	2 (18.2)	22
55-64	24 (8.1)	20 (23.5)	3 (50.0)	2 (10.0)	0 (0.0)	1 (9.1)	16
65+	49 (16.5)	4 (4.7)	1 (16.7)	5 (25.0)	0 (0.0)	2 (18.2)	20

Table 11: Demographic Characteristics, Average numbers and Column Percent Distribution of MVC-related TBI Hospitalizations by Person Injured during Crashes, 2008-2010

Person Injured	OCCUPANT	MOTOR CYCLE	PEDAL CYCLIST	PEDESTRIANS	OTHER	UNSPECIFIED	3 Year Ave
3-Year Ave	218 (65.5)	69 (20.7)	8 (2.4)	25 (7.5)	10 (3.0)	2 (0.6)	333
RACE							
Whites only	537 (82.0)	175 (84.5)	16 (66.7)	48 (63.2)	24 (77.4)	7 (100.0)	269
Blacks only	33 (5.0)	2 (1.0)	1 (4.2)	10 (7.9)	0 (0.0)	0 (0.0)	15
Others	26 (4.0)	6 (2.9)	1 (4.2)	6 (7.9)	3 (9.7)	0 (0.0)	14
Unknown	59 (9.0)	24 (11.6)	6 (25.0)	12 (15.8)	4 (12.9)	0 (0.0)	35
GENDER							
Male	399 (60.9)	168 (81.2)	23 (95.8)	43 (56.6)	19 (61.3)	7 (100.0)	219
Female	256 (39.1)	39 (18.8)	1 (4.2)	33 (43.4)	12 (38.7)	0 (0.0)	113
AGE GROUPS							
<15	41 (6.3)	6 (2.9)	9 (37.5)	16 (21.1)	1 (3.2)	2 (28.6)	25
15-24	198 (30.2)	31 (15.0)	5 (20.8)	15 (19.7)	6 (19.4)	2 (28.6)	85
25-34	102 (15.6)	35 (16.9)	1 (4.2)	9 (11.8)	4 (12.9)	2 (28.6)	51
35-44	87 (13.3)	46 (22.2)	2 (8.3)	3 (4.0)	5 (16.1)	1 (14.3)	48
45-54	78 (11.9)	55 (26.6)	5 (20.8)	8 (10.50	5 (16.1)	0 (0.0)	50
55-64	55 (8.4)	24 (11.6)	0 (0.0)	8 (10.5)	1 (3.2)	0 (0.0)	29
65+	94 (14.4)	10 (4.8)	2 (8.3)	17 (22.4)	9 (29.0)	0 (0.0)	44

Table 12: Demographic Characteristics, Average numbers and Column Percent Distribution of MVC-related TBI ED Visits by Person Injured during Crashes, 2008-2010

Person Injured	OCCUPANT	MOTOR CYCLE	PEDAL CYCLIST	PEDESTRIANS	OTHER	UNSPECIFIED	3-Year Ave
3 Year Ave	1530 (81.8)	144 (7.7)	46 (2.5)	71 (3.8)	67 (3.6)	10 (0.5)	1871
RACE							
Whites only	3628 (79.0)	375 (86.4)	105 (75.5)	158 (73.5)	143 (70.4)	28 (87.5)	1479
Blacks only	255 (5.5)	7 (1.6)	13 (9.3)	14 (6.5)	9 (4.4)	3 (9.4)	100
Others	134 (2.9)	8 (1.8)	3 (2.2)	9 (4.2)	12 (5.9)	0 (0.0)	55
Unknown	574 (12.5)	44 (10.1)	18 (12.9)	34 (15.8)	39 (19.2)	1 (3.1)	236
GENDER							
Male	2231 (48.6)	353 (81.3)	106 (76.3)	118 (54.9)	100 (49.3)	25 (78.1)	977
Female	2360 (51.4)	81 (18.7)	33 (23.7)	97 (45.1)	103 (50.7)	7 (21.9)	893
AGE GROUP							
<15	559 (12.2)	31 (7.1)	59 (42.5)	91 (42.3)	24 (11.8)	7 (21.9)	257
15-24	1728 (37.6)	108 (24.9)	21 (15.1)	36 (16.7)	86 (42.4)	9 (28.1)	662
25-34	762 (16.6)	72 (16.6)	18 (12.9)	19 (8.8)	24 (11.8)	2 (6.2)	299
35-44	494 (10.8)	80 (18.4)	12 (8.6)	13 (6.0)	23 (11.3)	5 (15.6)	209
45-54	470 (10.2)	84 (19.3)	21 (15.1)	18 (8.4)	24 (11.8)	4 (12.5)	207
55-64	282 (6.1)	45 (10.4)	5 (3.6)	8 (3.7)	8 (3.9)	5 (15.6)	117
65+	296 (6.4)	14 (3.2)	3 (2.2)	30 (13.9)	14 (6.9)	0 (0.0)	119

PART THREE: OVERALL BURDEN OF BRAIN INJURY HOSPITALIZATIONS

In this portion of the report, the burden of brain injury was assessed using hospitalization data as before. The burden consists of discharge location, length of stay (LOS), and charges, including expected source of payment (SOP). All hospitalization cases were analyzed including readmissions and transfers. Therefore, the total number of cases was greater than previously reported.

Hospital and ED Visits Discharge Locations, LOS, and Charges

Discharge location

Figure 27 depicts the discharge location of TBI patients that were hospitalized. From 2008 to 2010, 56% of hospitalized TBI cases were discharged home, 18% to long term care facilities (including skilled nurse facilities, hospice care), six percent were transferred to another inpatient hosptial, and 11% to rehabilitation services. About seven percent died during hospitalization.

The proportion of TBI patients that died was not different compared to previous reports. The proportion of cases discharged to long-term care and rehabilitation programs which increased from 24% to 30% advocates for the severity of cases that were hospitalized. TBI cases discharged from ED had better discharge outcomes than the hospitalized cases, with 90% of ED cases being discharged home and only seven percent transferred to inpatient services. The proportion of cases that died on arrival at the ED was less than 0.2%.

Table 13 describes the discharge location of TBI patients from hospitals and emergency departments by causes. Although not in the top three causes for hospitalizations, firearm-related TBI hospitalizations (9 cases) had the worst outcomes of all causes with 61% of cases resulting in death, 10% discharged to rehabilitation services, four percent to long term care and 10% transferred to other hospitals. Patients hospitalized because of fall had better individual outcomes with 60% of cases discharged home, 27% to long term care, seven percent to rehabilitation services, and eight percent to another hospital.

For patients received at the emergency department, firearm-related TBI had also the worst outcome with 22% dead on arrival and 35% transferred to another hospital. As for other causes of ED visits, such as fall, MVC and Struck by/ against, the proportion of patients who died was 0.1%, one and less than two percent, respectively. About seven percent of TBI-related ED visits, except for fireram, were transferred to another hospital.

Figure 27: Percent Distribution of TBI Discharge Type after Hospitalization or ED Visits, 2008-2010

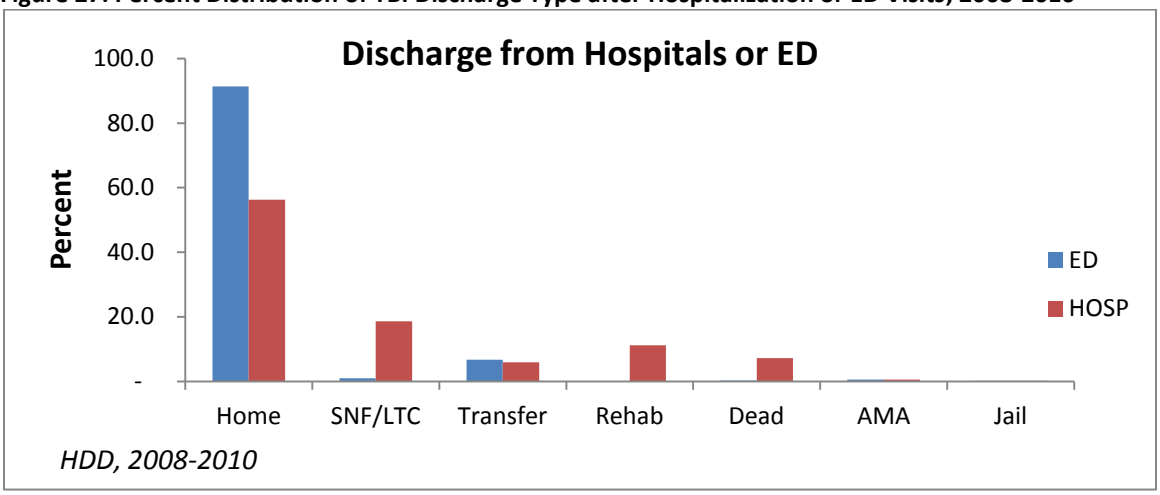


Table 13: Patient Discharge Type after TBI Hospitalizations and ED visits by Causes

CAUSE	SOURCE	3 YR AVE	Home	Transfer	SNF/LTC	AMA	Dead	Jail	Rehab
FALL	HOSP	752	60.0	7.6	**26.9**	0.4	6.7	0.1	**7.5**
	ED	7,769	90.7	7.0	1.8	0.4	0.1	0.1	0.0
MVC	HOSP	333	66.2	5.8	6.9	0.1	6.8	0.5	13.7
	ED	1,873	85.9	12.2	0.1	0.6	1.1	0.1	0.0
STRUCK BY/AGAINST	HOSP	81	87.8	2.4	2.0	2.9	2.0	0.4	2.4
	ED	3,733	96.5	2.6	0.1	0.5	0.0	0.2	0.0
FIREARM	HOSP	9	14.3	10.7	3.6	0	**60.7**	0	10.7
	ED	12	43.2	35.1	0.0	0.0	21.6	0.0	0.0
ALL CAUSES	HOSP	1,322	59.8	6.5	**17.6**	0.5	**6.6**	0.3	**8.7**
	ED	15,147	91.5	6.7	1.0	0.5	0.3	0.1	0.0

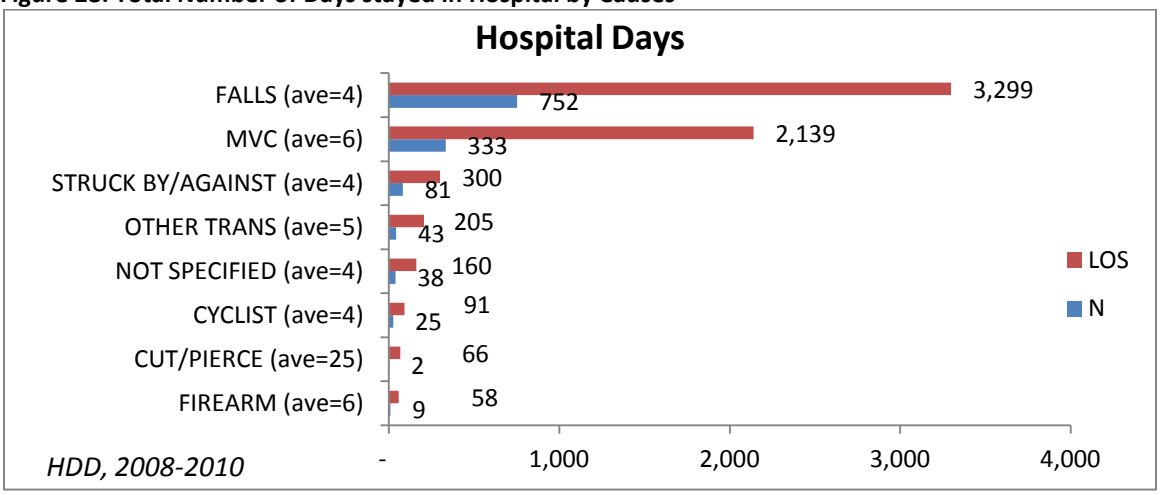
Note: *The numbers do not add to the total number of TBI cases because of missing E-codes and missing disposition.

Length of Stay (LOS)

The length of stay (LOS) had a wide range of vaues, from one day to up to 182 days with a greater average number of hospital days (5.1 days) than previous reports. MVC resulted in length of stay averaging six days, compared to fall with a mean LOS of four days. It can be noted that there was an increase in the average number of days in hospital particularly with MVC.

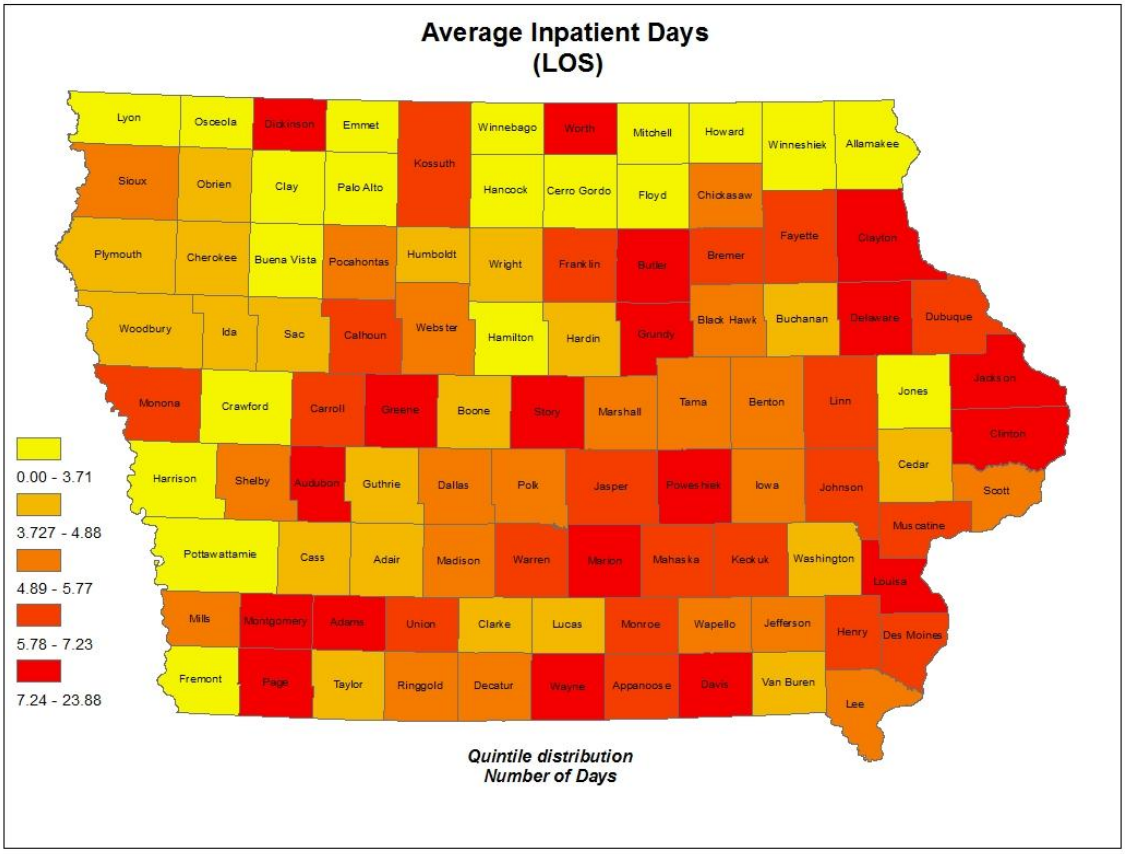
Fall was responsible for the highest average number of people hospitalized 752 (increased from 686 per year during last reporting period) and the higher total number of hospital stay days 3,299 (increased from 2,058). The annual average number of fall patients increased 9.6% compared to the previous 2006-2008 average. MVC had the second highest average number of hospitalizations, 333 events (decreased from 396 per year) with an average of 2,139 (increased from 1,584) hospitalized days annually (Figure 22). Despite the reduction in the total average number of MVC, the yearly total number of hospital days increased significantly (35%). These results highlight the increased severity of hospitalized cases due to MVC and fall.

Figure 28: Total Number of Days stayed in Hospital by Causes



Note: *The numbers may not correspond to number of TBI cases because of missing E-codes, missing disposition and missing los.

Figure 29: Average Number of Inpatient Days by County, 2008-2010



Hospital Charges and Expected Source of Payment

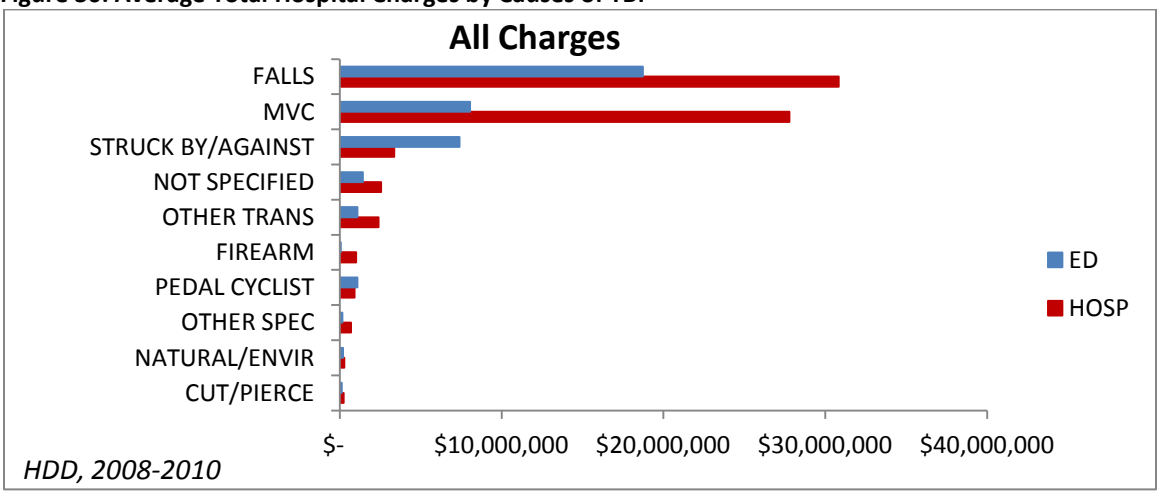
Charges

The three-year average total TBI-related hospital charges for all cases amounted to $82 million with a mean of $40,000 (Median: $18,800). When limited to individual cases (or first encounters), charges totaled $71 million for hospitalizations, which represents a 75% increase from previous reporting period. The mean charge (per individual) was $37,000 (Median $17,000). ED visit charges totaled $42 million with a mean around $2,600 per visit (median $2,000).

Overall, there was a notable increase in hospital and ED visit charges compared to the previous 2008-2010 report, reflecting the severity of hospitalized cases. However, these results need to be interpreted with caution as charges do not represent the true cost of TBI which should be adjusted for inflation, business practices and do not include the cost of outcomes, such as death, pain and suffering or property loss .[4]

The mean charge for a hospitalized MVC-related TBI was a little over $23,000. The mean charge for a MVC-related ED visit was $2,600. The total charges per year for MVC-related TBI hospitalization and ED visit totaled $27 million. TBI hospitalizations due to fall were charged on average $12,000 and ED visits were charged an average of $1,500. Firearm treatment charges following a hospitalization reached the bar of $19,000 per case, per year, for an average total of $620,000. The firearm-related TBI hospitalizations averaged 12 cases per year.

Figure 30: Average Total Hospital Charges by Causes of TBI



SOP

Figure 31 and figure 32 show the distribution of the expected payment sources and total amounts charged (three-year average), respectively for hospitalizations and ED visits.

Private insurances were charged for about 47% of hospitalizations and 45% of ED visits. Hospitalization charges to private payers totaled, on average, over $34 million per year, which corresponded to 36%

increase from the previous average amount of $25 million in 2006-2008. Emergency Department Visits charged to private payers averaged $18 million per year.

The federal government through Medicaid, Medicare and other programs was charged, on average, $31 million (72% increase from the previous $18 million) annually, which corresponded to 44% of the total charges for the hospitalized cases. For Emergency department visits, the annual average charges amounted to $15 million, corresponding to 39% of the total TBI charges. State and local funds including worker's compensation were expected to be responsible for five percent of charges associated with TBI hospitalizations and ED visits. Individuals (out-of-pocket) were responsible for six percent of hospitalization and 13% of ED visit charges. These charges respectively amounted to three and five million dollars.

Table 14 and 15 summarize the total average hospital and ED visit charges of TBI causes by source of pay. For 2008-2010, fall contributed to the highest share of hospital charges ($31 million) and ED visits ($18 millions) as well, taking the lead from MVC hospitalization ($28 million) and ED visits ($8 million) financial burden in this reporting period. MVC hospitalizations were typically charged to private payers and fall hospitalizations were mostly billed to federal insurance payers. The MVC and fall payment ratio (federal vs. private) were equally at 3:1 ratio. For every $1 charged to federal payers on MVC-related TBI, $3 was charged to privates. And for every $1 charged to private insurances for fall-related TBI, $3 was charged to federal payers. However, for ED visits, MVC-related TBI were generally charged to the private sector (ratio 5:1) while fall were almost equally billed (ratio less than 2:1) to federal and private payers. Many reasons may be given to explain the differences in billing charges. The data showed that most of private payers are related to motor vehicle crashes, which present a greater LOS and worse debilitating outcomes. Another reason is that Medicare and Medicaid have different reimbursement rate or fee-for-service scale than private insurers.

In this report, we investigated per capita charges by county, which represent the average annual charges for TBI hospitalization divided by county population. This indicator may represent how much each county resident would participate if the charges were solely paid by the county taxpayers. The quartile distribution showed rural counties with low population among the lowest quartile. However, counties with major hospital centers did not belong to the quartile with highest per capita charges (Figure 33).

Figure 31: Total Charges for TBI Hospitalizations by Expected Source of Pay

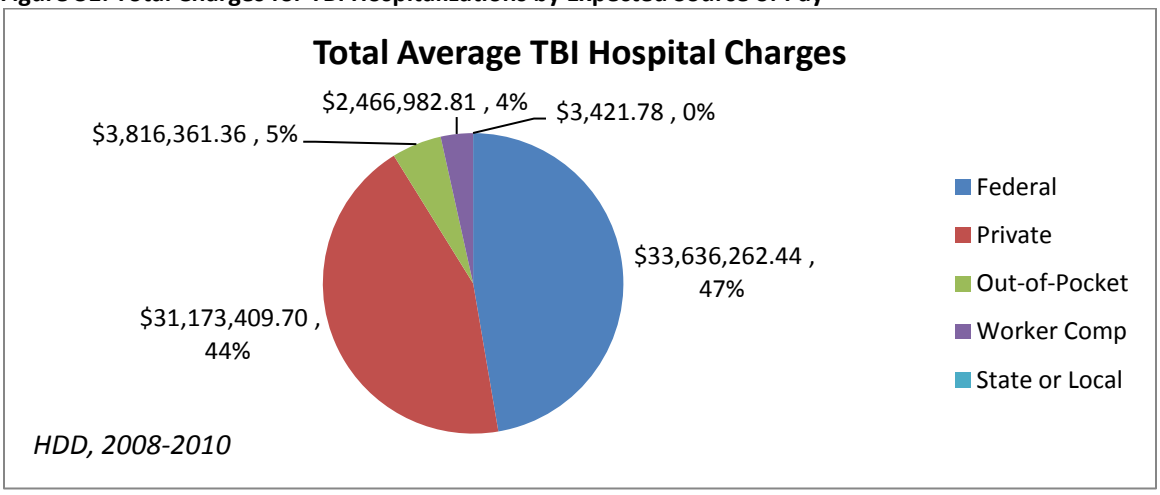


Figure 32: Total Charges for TBI ED Visits by Expected Source of Pay

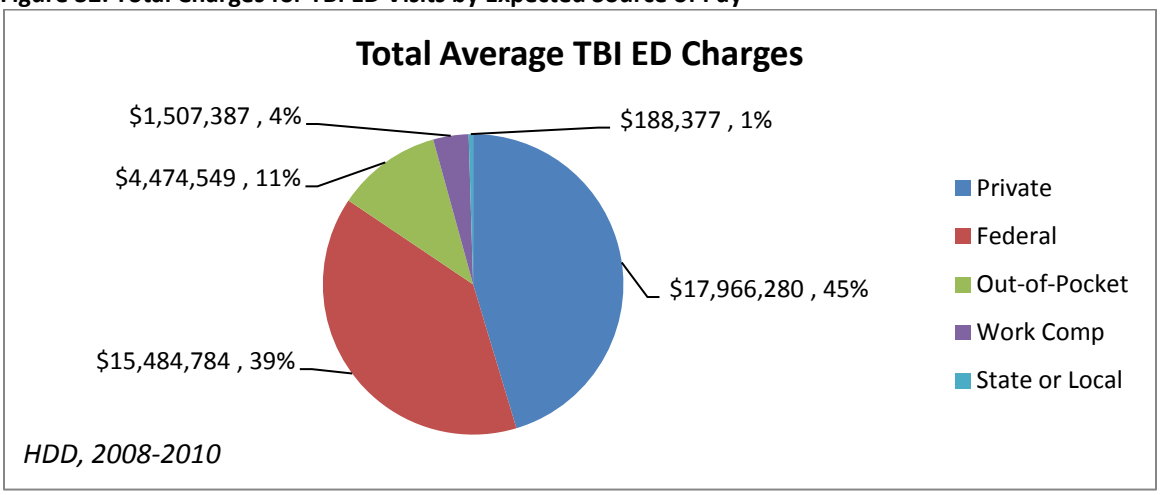


Table 14: Total Hospital Charges by Causes and Expected Source (Dollars)

CAUSE	Federal	Private	State or Local	Worker Comp	Out-of-Pocket	Grand Total
FALL	22494571.2	6145587.4	3421.8	1166396.7	1028052.1	30838029.2
MVC	5492552.2	19841896.7	-	768084.4	1689768.9	27792302.1
STRUCK BY/AGAINST	1414232.4	1325724.3	-	226948.5	406084.8	3372990.0
NOT SPECIFIED	1526571.4	778812.3	-	7458.5	239942.3	2552784.5
OTHER TRANS	486562.8	1680569.7	-	111958.3	111521.4	2390612.2
FIREARM	437131.6	453290.1	-	-	125038.9	1015460.6
PEDAL CYCLIST	418061.2	430207.9	-	-	67289.7	915558.8
OTHER SPEC	481728.0	63782.5	-	116142.3	25598.1	687250.9
NATURAL/ENVIR	127268.2	140626.7	-	16907.5	1906.5	286708.8
CUT/PIERCE	175157.2	15299.8	-		52641.2	243098.1
FIRE/BURN	158244.7	64956.0	-		-	223200.7
MACHINERY	88094.1	52043.8	-	53086.7	-	193224.6
NEC	110339.2	33373.6	-	-	44915.3	188628.0
OTHER PEDESTRIAN	44099.7	105068.4	-	-	16047.5	165215.6
POISONING	111316.8	21531.0	-	-	7554.7	140402.5
SUFFOCATION	70332.0	16203.2	-	-	-	86535.2
DROWNING		4436.3	-	-	-	4436.3
Grand Total	33636262.5	31173409.7	3421.8	2466982.8	3816361.4	71096438.1

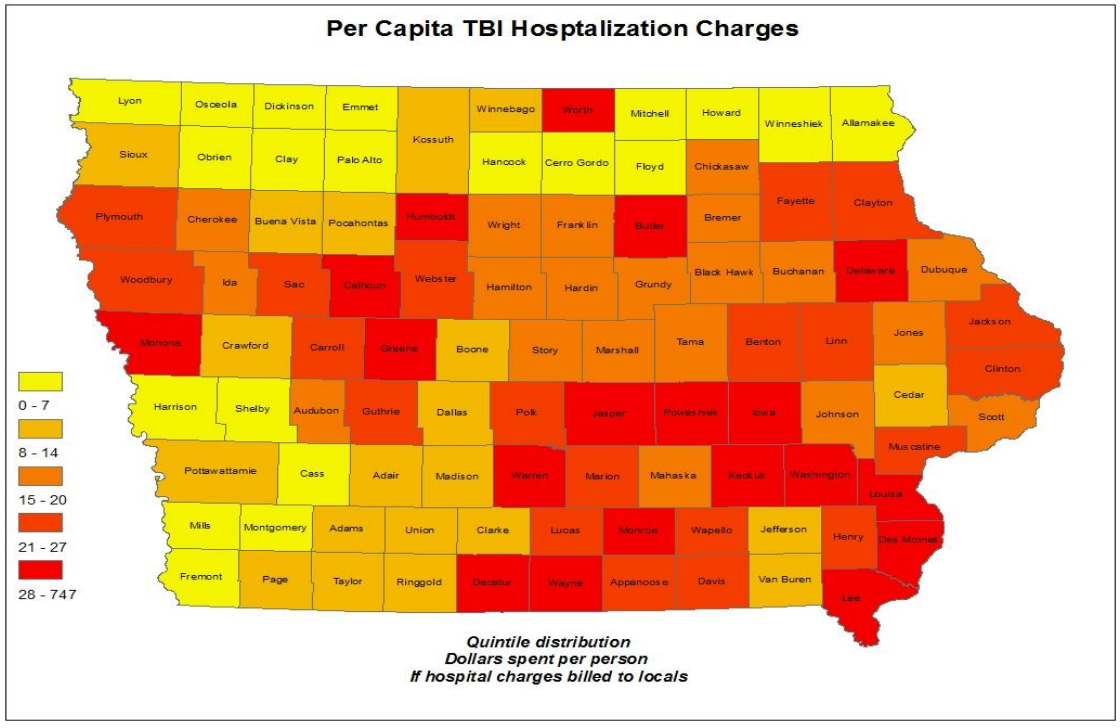
Notes: MVC= motor vehicle crashes; TRANS= other transportation, SPEC= specified, ENVIR= environment, NEC= not expressly coded ;

Table 15: Total ED Visit Charges by Causes and Expected Source (Dollars)

CAUSE	Federal	Private	Work Comp	State or Local	Out-of-Pocket	Grand Total
FALL	10610222	6241611	663147	59352	1160137	18734470
MVC	1230788	5434445	324357	36450	1027262	8053302
STRUCK BY/AGAINST	2058530	3622786	389532	51633	1268517	7390997
OTHER TRANS	266957	971867	24558	2900	164852	1431134
NOT SPECIFIED	548552	479771	34232	7441	350528	1420525
CYCLIST	328437	647658	696	3726	116094	1096610
NEC	248562	203071	11419	25711	243354	732118
NATURAL/ENVIR	29430	141511	6308	-	26962	204212
OTHER SPEC	51203	68971	18803	92	29300	168371
CUT/PIERCE	31490	54035	5766	-	39205	130496
MACHINERY	17699	26903	23747	-	4309	72658
FIREARM	26361	19811	735	-	15951	62858
OTHER PEDESTRIAN	9641	26471	989	-	4076	41178
POISONING	6679	16200	1462	1072	9465	34878
OVEREXERTION	10053	5692	1198	-	9636	26579
SUFFOCATION	7910	1232	-	-	1561	10703
DROWNING	1249	2234	-	-	2207	5691
FIRE/BURN	1021	2011	437	-	1130	4599
Grand Total	15484784	17966280	1507387	188377	4474549	39621377

Notes: MVC= motor vehicle crashes; TRANS= other transportation, SPEC= specified, ENVIR= environment, NEC= not expressly coded ;

Figure 33: Per Capita Charges (dollars) for TBI-related Hospitalizations by County, 2008-2010



CONCLUSIONS AND RECOMMENDATIONS

TBI remains a source of great concern in Iowa and continues to have negative impact in the lives of thousands of Iowans every year. Demographic distributions show an increased burden of TBI in males and older adults over the report time period. Although deaths, hospitalizations and ED visits were decreasing, the number of TBI among the elderly because of fall significantly increased . Firearm rose to the forefront as the second leading cause of TBI deaths as the number of fatal MVC were reduced.

County size classification showed the overall rates of TBI were different across the county sizes. Smaller counties, considered more rural, had greater rates of MVC and firearm-related TBI hospitalizations than more populated counties.

Inpatient data show fall as the leading cause of TBI in adults over the age of 45 years. Motor vehicle crashes were prevalent in younger adults between the ages of 15 and 45, and were associated with acute medical costs.

Hospital and ED visit charges increased significantly despite the reduction in MVC. Private insurance companies were more likely to be charged for MVC compared to governmental entities, which were charged for fall-related TBI hospitalizations and ED visits. Though, it is important to note that different payers were billed different rates depending on their business status (e.g., private payers vs. governmental), private insurance expected payment significantly decreased while federal share in payment increased.

Surveillance data are limited to death and hospital discharges, the need for real time data is critical, however barriers to timely reporting limit the efficiency of TBI surveillance. This delay in timely assessment and analysis of the Hospital Discharge Data can be alleviated by analyzing the quarterly data file the Iowa Hospital Association provides to IDPH. Quarterly analysis will reduced the data delay to six months. Futhermore, as the state trauma registry (STR) evolves, protocols and requirement for trauma coordinators to report in a timely manner (upon discharge and not quarterly) ALL patients (and not just a few to meet requirement) should be recommended. In addition, after successful discharge TBI survivor surveillance should include a prospective assessment of their physical and emotional conditions using the Brain Injury Alliance of Iowa (BIAIA) database. And finally, TBI surveillance assessment, analysis and reporting should include in the future the state trauma registry data. Since only the STR, despite its limitations (not all Iowa hospitals are reporting), can provide detail information on risk factors during pre-hospital management, hospitalizaion and after discharge.

Families of individuals with brain injury face overwhelming challenges not only in dealing with their loved one's injury,but also in finding adequate services in a confusing and frustrating delivery system. Under the leadership of the Advisory Council on Brain Injuries (ACBI), the department partners with the Brain Injury Alliance of Iowa (BIAIA) and the Association of Community Providers (ACP) to create a better future for survivors through brain injury prevention, education, advocacy and support.

APPENDIXES

KEY EPIDEMIOLOGICAL TERMS

- **Adjustment method**: A rate that is statistically modified to eliminate the effect of different age distributions in the population over time, or between different populations by using direct or indirect methods with a reference population (ex. Census 2000). The Direct method assumes that the observed population had the same distribution of characteristics (ex. age, gender, race etc.) as the reference population. The indirect method assumes that the observed population had the experience (outcome/disease distribution) of the reference population.
- **Age-adjusted Mortality rate** is a mortality rate that has been statistically modified to eliminate the effect of different age distributions among different populations.
- **Age-specific Mortality rate** is a mortality rate limited to a particular age group, calculated as the number of deaths among the age group divided by the number of persons in that age group usually expressed per 100,000.
- **Incidence**: A measure of the frequency with which new cases of illness, injury, or other health conditions occur among a population during a specified period
- **Measure of association**: a quantified relationship between exposure and a particular health problem (e.g., risk ratio, rate ratio, and odds ratio).
- **Attributable Risk**: Measure of how much of the disease burden could be eliminated if the exposure were eliminated. Alternately, the rate of a disease or other outcome in exposed individuals that can be attributed to the exposure.
- **Rate**: An expression of the frequency with which an event occurs in a defined population in a specified period of time, often one year.
- **Ratio**: The value obtained by dividing one quantity by another.
- **Relative Risk**: The ratio of incidence of a disease, condition, or event in one group to that in another group. A comparison of the risk of some health-related event such as disease or death in two groups.
- **Odds Ratio**: A measure of association which quantifies the relationship between an exposure and health outcome from a comparative study.
- **Percentage** (proportion): A type of ratio in which the numerator is included in the denominator. The ratio of a part to the whole, expressed as a decimal fraction, a fraction, or with a percentage sign (%)

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